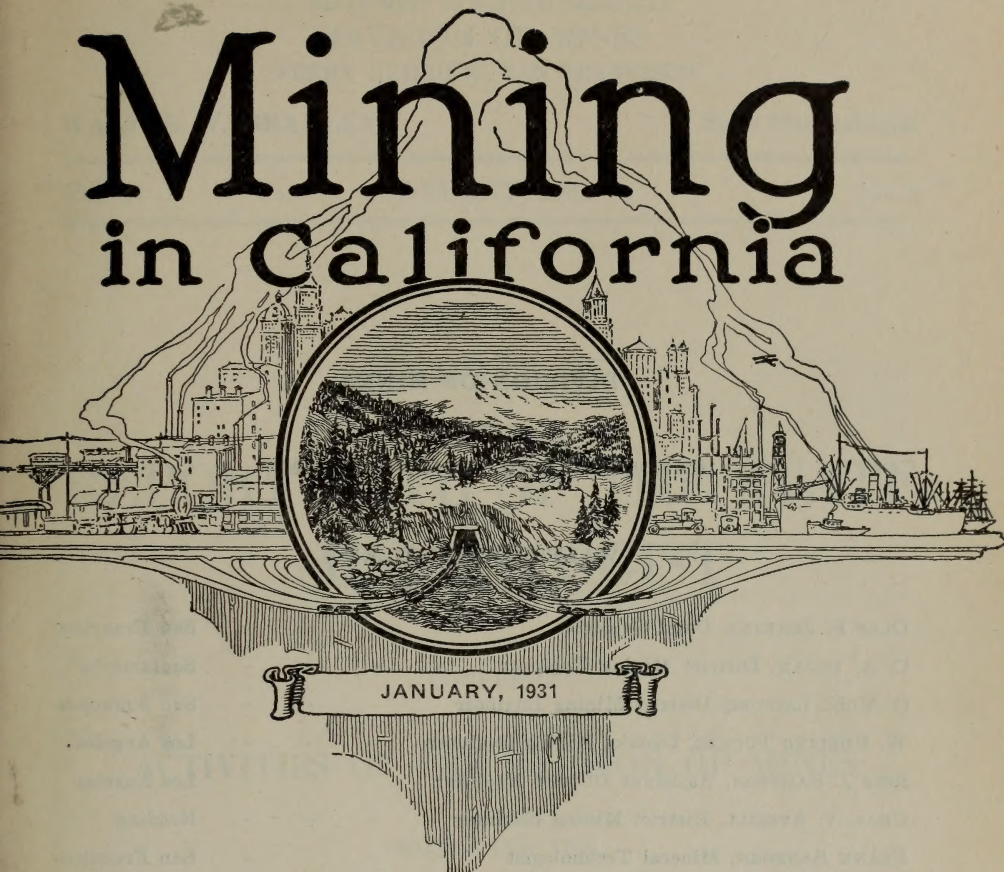

PUBLISHED QUARTERLY

STATE OF CALIFORNIA
DEPARTMENT OF NATURAL RESOURCES
DIVISION OF MINES

FERRY BUILDING
SAN FRANCISCO

DIVISION OF MINES

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STATE OF CALIFORNIA
DEPARTMENT OF NATURAL RESOURCES
DIVISION OF MINES
FERRY BUILDING, SAN FRANCISCO

WALTER W. BRADLEY State Mineralogist

Vol. 27 JANUARY, 1931 No. 1

CHAPTER OF

REPORT XXVII OF THE STATE MINERALOGIST

COVERING

ACTIVITIES OF THE DIVISION OF MINES

INCLUDING THE

GEOLOGIC BRANCH

CALIFORNIA STATE PRINTING OFFICE
HARRY HAMMOND, STATE PRINTER
SACRAMENTO, 1931

TABLE OF CONTENTS

	Page
DISTRICT REPORTS OF MINING ENGINEERS	1
Redding Field Division	3
Economic Geology of Shasta Quadrangle	3
Sacramento Field Division	66
San Francisco Field Division	66
Los Angeles Field Division	66
GEOLOGIC BRANCH	67
OIL FIELD DEVELOPMENT OPERATIONS	78
SPECIAL ARTICLES	83
Beryllium and Beryl	83
The New Tariff and Nonmetallic Products	98
Crystalline Talc	100
Decorative Effects in Concrete	105
ADMINISTRATIVE	112
MINERALS AND STATISTICS	113
Statistics	113
Museum	114
Laboratory	114
LIBRARY	115
PRODUCERS AND CONSUMERS	127
EMPLOYMENT SERVICE	127
PUBLICATIONS	I

PREFACE

The Division of Mines (formerly State Mining Bureau) is maintained for the purpose of assisting in all possible ways in the development of California's mineral resources.

As one means of offering tangible service to the mining public, the State Mineralogist for many years has issued an annual or a biennial report reviewing in detail the mines and mineral deposits of the various counties.

As a progressive step in advancing the interests of the mineral industry, and as permitting earlier distribution to the public, publication of the Annual Report of the State Mineralogist in the form of monthly chapters was begun in January, 1922, and continued until March, 1923.

Owing to a lack of funds for printing this was changed to quarterly publication, beginning in September, 1923.

For the same reason, beginning with the January, 1924, issue, it has been necessary to charge a subscription price of $1 per calendar year, payable in advance; single copies, 25 cents apiece. 'Mining in California' is sent without charge to our 'exchange list,' including schools and public libraries, as are also other publications of the Division of Mines.

Pages are numbered consecutively throughout the year and an index to the complete report is included annually in the closing number.

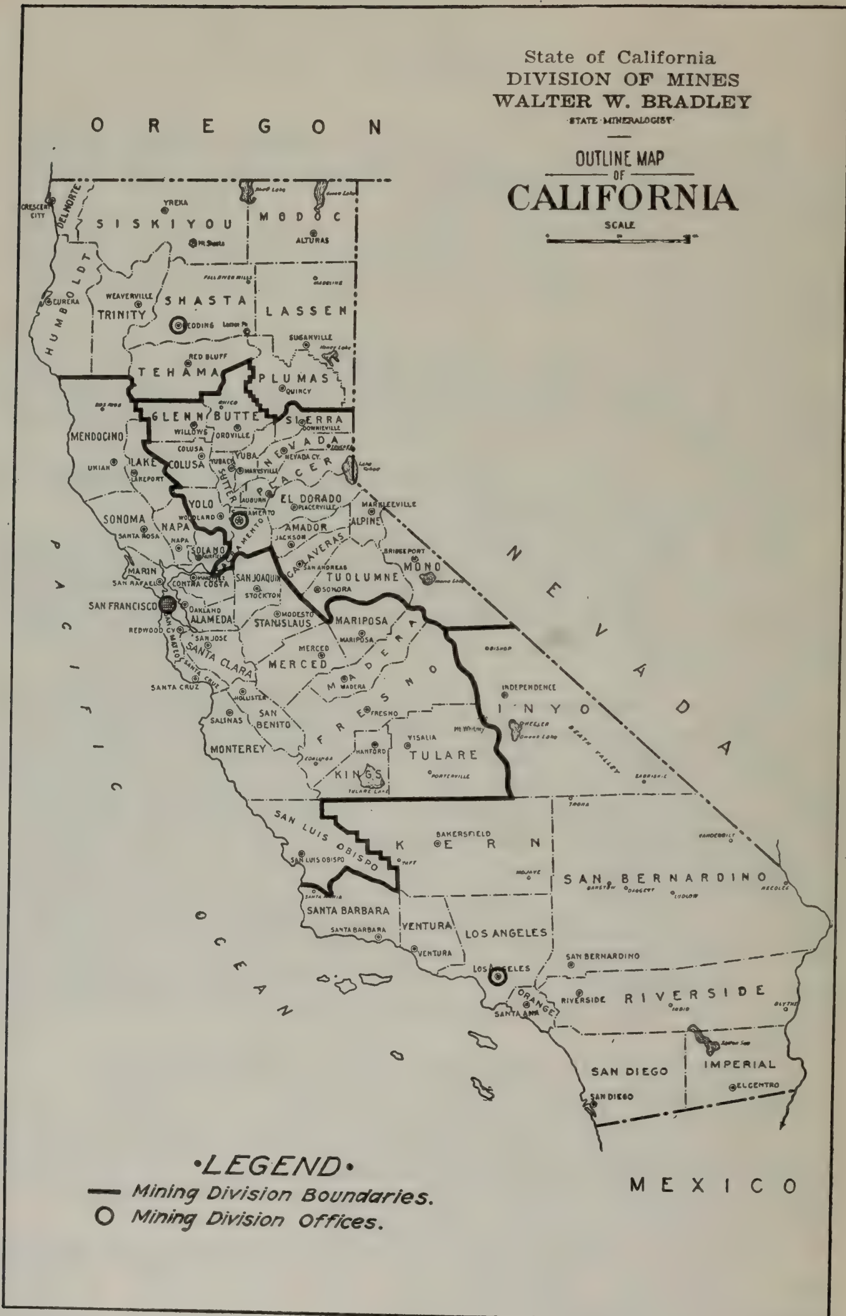
Such a publication admits of several improvements over the old method of procedure. Each issue contains a report of the current development and mining activities of the State, prepared by the district mining engineers. Special articles dealing with various phases of mining and allied subjects by members of the staff and other contributors are included. Mineral production reports formerly issued only as an annual statistical bulletin are published herein as soon as returns from producers are compiled. The executive activities, and those of the laboratory, museum, library, employment service and other features with which the public has had too little acquaintance also are reported.

Beginning with the 1930 issues, the activities and progress of the Geologic Branch are recorded also in these quarterly chapters.

While current activities of all descriptions are covered in these chapters, the practice of issuing from time to time technical reports on special subjects will be continued, as well. A list of such reports now available is appended hereto, and the names of new bulletins will be added in the future as they are completed.

The chapters will be subject to revision, correction and improvement. Constructive suggestions from the mining public are gladly received, and are invited.

The one aim of the Division of Mines is to increase its usefulness and to stimulate the intelligent development of the wonderful, latent resources of the State of California.


State of California
DIVISION OF MINES
WALTER W. BRADLEY
STATE MINERALOGIST
OUTLINE MAP
OF
CALIFORNIA
SCALE
OREGON
NEVADA
MEXICO
PACIFIC
OCEAN
SISKIYOU
MODOC
DEL NORTE
HUMBOLDT
TRINITY
SHASTA
LASSEN
TEHAMA
PLUMAS
GLENN
BUTTE
SIERRA
NEVADA
MENDOCINO
LAKE
COLUSA
YUBA
SUTTER
PLACER
YOLO
EL DORADO
SONOMA
NAPA
SOLANO
SACRAMENTO
AMADOR
ALPINE
MARIN
CONTRA COSTA
SAN JOAQUIN
CALAVERAS
TUOLUMNE
MONO
SAN FRANCISCO
ALAMEDA
STANISLAUS
MARIPOSA
SAN MATEO
SANTA CLARA
SANTA CRUZ
MERCED
MADERA
SAN BENITO
MONTEREY
FRESNO
INYO
TULARE
KINGS
SAN LUIS OBISPO
KERN
SAN BERNARDINO
SANTA BARBARA
VENTURA
LOS ANGELES
ORANGE
RIVERSIDE
SAN DIEGO
IMPERIAL
CRESCENT CITY
YREKA
ALTURAS
WEAVERVILLE
EUREKA
REDDING
SUSANVILLE
RED BLUFF
QUINCY
CHICO
WILLOWS
OROVILLE
DOWNIEVILLE
COLUSA
NEVADA CY.
MARYSVILLE
UKIAH
LAKEPORT
AUBURN
PLACERVILLE
MARKLEEVILLE
WOODLAND
SACRAMENTO
SANTA ROSA
NAPA
JACKSON
BRIDGEPORT
SAN RAFAEL
SAN ANDREAS
SONORA
STOCKTON
OAKLAND
MODESTO
REDWOOD CY.
SAN JOSE
MERCED
SANTA CRUZ
HOLLISTER
MADERA
FRESNO
INDEPENDENCE
SALINAS
VISALIA
HANFORD
BAKERSFIELD
SAN LUIS OBISPO
SANTA BARBARA
VENTURA
LOS ANGELES
SAN BERNARDINO
RIVERSIDE
SANTA ANA
SAN DIEGO
EL CENTRO
•LEGEND•
Mining Division Boundaries.
Mining Division Offices.

DISTRICT REPORTS OF MINING ENGINEERS

In 1919–1920 the Mining Bureau was organized into four main geographical divisions, with the field work delegated to a mining engineer in each district, working out from field offices that were established in Redding, Auburn, San Francisco and Los Angeles, respectively. This move brought the office into closer personal contact with operators, and it has many advantages over former methods of conducting field work. In 1923 the Redding and Auburn field offices were consolidated and moved to Sacramento.

The Redding office was reestablished in 1928, and the boundaries of each district adjusted. The counties now included in each of the four divisions, and the locations of the branch offices, are shown on the accompanying outline map of the state. (Frontispiece.)

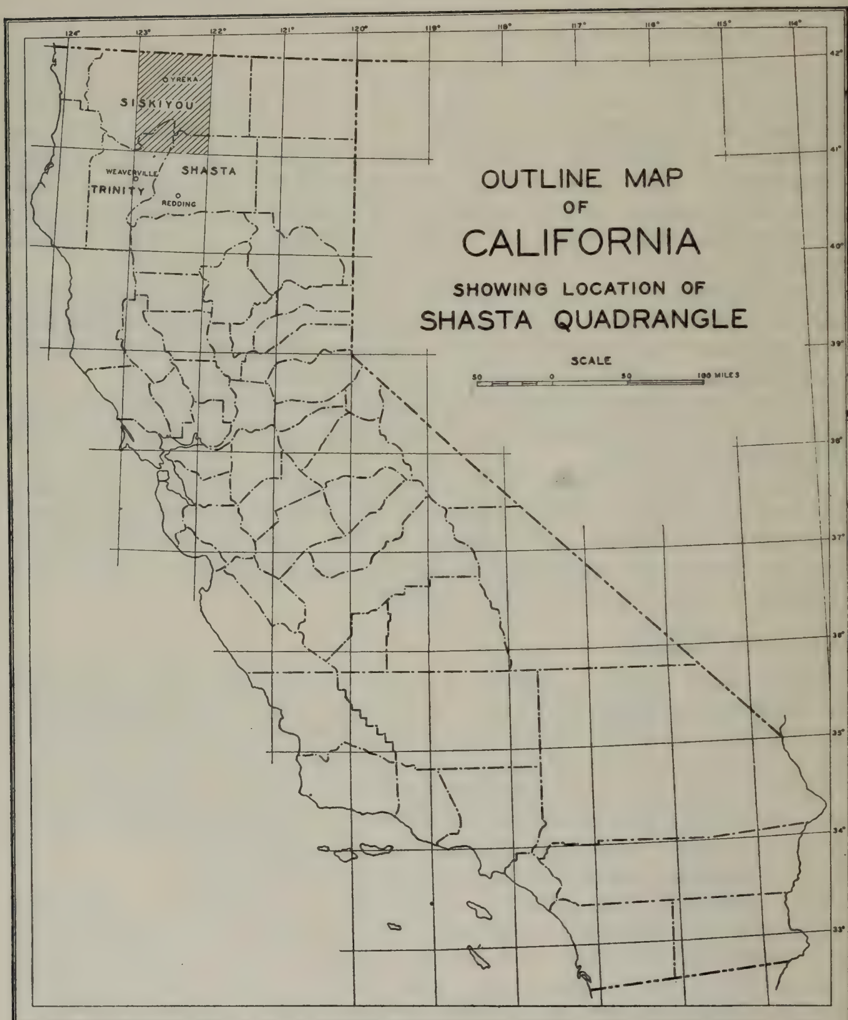
Reports of mining activities and development in each division, prepared by the district engineer, will continue to appear under the proper field division heading.

Although the petroleum industry is but little affiliated with other branches of mining, oil and gas are among the most valuable mineral products of California, and a report by the State Oil and Gas Supervisor on the current development and general conditions in the state's oil fields is included under this heading.

New County Reports.

The series of separate reports on the mines and mineral resources of the different counties, that together comprise the State Mineralogist's Reports XIV to XVII, inclusive, in the case of many of the counties having become exhausted and those still in stock being in need of revision, it was deemed advisable, beginning with the January, 1925, issue of 'Mining in California,' to make the district engineers' reports in the form of a complete general report on the mines and mineral resources in one or more of the counties in each district.

That program was followed as nearly as possible in succeeding numbers of the quarterly, and the series on the basis of county areas were completed with the 1930 issues. Attention for the current biennium (1931–1932) is being given principally to state-wide reports on specific minerals of the nonmetallic groups, and to economic geology.


OUTLINE MAP
OF
CALIFORNIA
SHOWING LOCATION OF
SHASTA QUADRANGLE
SCALE
50
0
50
100 MILES
YREKA
SISKIYOU
WEAVERVILLE
SHASTA
TRINITY
REDDING
124°
123°
122°
121°
120°
119°
118°
117°
116°
115°
114°
42°
41°
40°
39°
38°
37°
36°
35°
34°
33°

REDDING FIELD DIVISION

By Chas. Volney Averill, Mining Engineer

PRELIMINARY REPORT ON ECONOMIC GEOLOGY OF THE SHASTA QUADRANGLE

Geography.

The Shasta quadrangle covers an area in north-central California, bordering on the State of Oregon, and lying between 41 and 42 degrees north latitude, 122 and 123 degrees west longitude. Parts of Klamath Mountains and Cascade Range are within it, including Mt. Shasta. The largest part of the area lies in Siskiyou county, with the county seat, Yreka, near the center, but portions of Shasta and Trinity counties are also included. In a north and south direction, about 70 miles are covered, and in an east and west direction, about 50 miles. The area is over 3500 square miles, or considerably more than the combined area of the states of Rhode Island and Delaware.

With the exception of two large, fertile valleys, the Shasta and the Scott, the region is mountainous. Shasta Valley, in the center of the quadrangle, at an elevation a little under 3000 feet, is separated from Scott Valley by mountains to the west reaching elevations of more than 6000 feet. Scott Valley is smaller than Shasta Valley, and is at about the same elevation. A few areas of comparatively flat land are found in the lava region along the eastern border of the quadrangle, otherwise it is very rugged. Mt. Shasta lies southeast of Shasta Valley and rises to an elevation of 14,380 feet. Around the borders of the larger valleys, in an area comprising 90 per cent of the quadrangle, elevations of 6000 and 8000 feet are common. The boundary between Klamath Mountains and Cascade Range, as shown by Diller [1] on the basis of geology, enters the quadrangle near the center of the north end, and passes out of the east side near the south end. The mountains formed of the later lavas are part of Cascade Range, while Klamath Mountains are made up of much older rocks.

The general topography of the area is given by the Shasta quadrangle of the United States Geological Survey. This is, however, a reconnaissance sheet only, not accurate enough for use in mapping areal geology. A more detailed topographical map, covering much of the south half of this quadrangle, and drawn on a scale of a mile to an inch, has recently been published by the Forest Service.[2]

Streams flow both north and south from a divide that includes Mt. Shasta. Shasta River runs north to Klamath River, the course of which, within the quadrangle, is westward. Scott River, another tributary of the Klamath, drains a large area to the west. The streams flowing south from near Mt. Shasta, empty into Sacramento River, while those further west flow into Trinity River. Minor portions of the rugged country in the southwest corner are within the basin of Salmon River.

[1] Diller, J. S., Auriferous gravels in the Weaverville Quadrangle, California: U. S. Geol. Survey Bull. 540, Part I, pp. 11–21, fig. 1, 1912.

[2] U. S. Department of Agriculture, Forest Service, Shasta National Forest (West Half), 1929.

Climate.

The accompanying table shows figures on precipitation and temperatures for points within the Shasta quadrangle at which the United States Weather Bureau[3] has maintained stations. Various periods are represented, all earlier than 1923.

Place	*Elevation*	*Average annual precipitation, inches*	*Average seasonal fall of snow, inches*	*Mean temperature*	*Highest temperature*	*Lowest temperature*
Dunsmuir	2285	57.06	70.5	---	---	--
Hornbrook	2154	14.47	---	---	105	—12
Macdoel	4258	15.07	44.3	43.7	102	—15
McCloud	3270	45.18	119.7	48.4	101	— 3
Montague	2450	12.21	---	51.2	108	—10
Mt. Shasta City	3555	35.59	117.3	48.8	108	— 9
Yreka	2625	17.49	---	50.8	108	— 4

Some snow falls everywhere in the quadrangle; and the per cent of the total precipitation that falls as snow increases rapidly with elevation. Prevailing winds during storms are from the south and southwest. A comparison of figures for precipitation at points north of Mt. Shasta with those at points south shows that by far the greater amount of moisture falls south of this divide. Heavy storms come in the months of November, December, January (the heaviest), February and March. Some may come in April, May, September and October, while June, July and August are usually quite dry.

Industries.

The population of the area is roughly 20,000 persons, supported largely by agriculture, grain, hay and stock raising. In the two large valleys are extensive tracts of irrigated lands. Smaller tracts are scattered throughout the area, and a large acreage of foothill land is devoted to farming, stock raising and grazing.

Lumbering is an important industry, the operations of the McCloud River Lumber Company being very extensive. Smaller mills are located at Weed, Mt. Shasta City and Castella. In the National Forests, which now include nearly all of the mountainous parts of the quadrangle, are large reserves of fine timber. Power is generated by the California-Oregon Power Company at Copco. During the summer and fall months the area is a favorite with campers, tourists, fishermen and hunters.

Transportation is furnished by a line of the Southern Pacific running north and south nearly through the center of the quadrangle, with a second line from near Mt. Shasta to Klamath Falls in Oregon. There is also a rail connection to McCloud and points east. A paved state highway nearly parallels the north and south railroad line, running through Castella, Dunsmuir, Mt. Shasta City, Weed, Yreka and Hornbrook. Good highways reach down Klamath River for 20 miles, and to Fort Jones, Etna, Montague, and McCloud, while numerous gravel and dirt roads give access to nearly all parts of the area except the higher mountains. The U. S. Forest Service is building roads that rise on a gentle grade to elevations of 6000 feet and more.

Mining, particularly for gold, is not as active in this area as it has been at times in the past. Mineral resources include asbestos, barite,

[3] U. S. Department of Agriculture, Weather Bureau, Summary of Climatological Data for the United States by Sections, Reprints of Sections 15 and 16.

chromite, coal, copper, gems, gold, lead, limestone, marble, mineral water, platinum, quicksilver, and stone. These will be considered in order in the section on economic geology.

General Geology.

In a general way the line of the Southern Pacific Railroad, which follows Sacramento River and then roughly Shasta River and Cottonwood Creek, separates the quadrangle into two parts geologically. The part to the west is occupied by the older sediments and intrusive rocks of Klamath Mountains, while that to the east is a part of Cascade Range, composed of later rocks, Tertiary and Quaternary lavas including some sediments. An exception to this is an area roughly 15 miles square in the southeast corner, where are found Devonian, Carboniferous, Triassic and Jurassic sediments with intrusives, hence, this corner is considered a part of the Klamath Mountains.

While the eastern portion of the quadrangle is of some economic value as a source of building stone, crushed rock, pumice and agate, its importance as a source of minerals is small as compared to that of the western portion; and it is treated but briefly in the present report. The complicated series of lava flows should make a very interesting study in volcanism for some geologist, but it would require a large amount of time. A start has been made by Diller[4] on Mt. Shasta; but the area covered by him is only a small fraction of the lava beds of this region. His map, covering an area nearly 25 miles square, with Mt. Shasta in the center, shows three kinds of lava: basalt, hypersthene andesite, and hornblende andesite. A flow of pyroxene andesite from Mt. Shasta followed Sacramento River for many miles south of the Shasta quadrangle and into the region mapped by the Redding quadrangle.

Historical Geology.

The oldest rocks of the quadrangle consist of mica schist, a metamorphic product, known as the Abrams[5] schist, apparently derived from a sedimentary series. In age, it is pre-Devonian.[6] A hornblende rock, known as the Salmon[7] schist, also a metamorphic product, but in this case probably derived from igneous material, is another of the older series. Besides these formations, much schist has been included on the accompanying map in the unit designated, 'Early Paleozoic and possibly pre-Paleozoic sediments and schists, (P).' In part, these metamorphic rocks may be of Devonian age, and part comparable to the Abrams and Salmon schists. Our present knowledge of their ages is incomplete.

In pre-Devonian times, there was a long period of volcanism, evidenced by large areas of metamorphic products of volcanic material, i. e., greenstone and Copley meta-andesite. Shales, cherts, and limestones of Devonian age were later deposited, then uplifted and much eroded, while the products of erosion contributed to the still later

[4] Diller, J. S., Mount Shasta, Some of its geologic aspects: Mazama, vol. 4, No. 4, Dec., 1915, Portland, Oregon.
[5] Hershey, O. H., Am. Jour. Sci., Vol. 184, pp. 263–273.
[6] Hershey, O. H., Metamorphic formations of northwestern California: Am. Geologist, Vol. 27, p. 245, 1901.
Diller, J. S., U. S. Geol. Survey, Redding Folio, No. 138, p. 10, 1906.
[7] Hershey, O. H., *Idem.*

Columnar structure in lava (pyroxene andesite) which flowed from Mt. Shasta. Lava is overlain by recent gravels and underlain by Copley meta-andesite. Location, on the highway near Hazel Creek. Photo by O. P. Jenkins.

sediments which make up the Bragdon formation of Carboniferous age. An extensive uplift followed, raising portions of Klamath Mountains above the sea. Apparently, during Triassic and Jurassic times, only the southeast corner of the quadrangle was submerged. At about that time extensive activities in mountain-building took place and many large igneous masses were intruded. Evidences of the intrusions are in all sediments earlier than the Cretaceous, whose conglomerate beds contain pebbles of many kinds of igneous rocks. Not all the intrusives, however, should be assigned to one period. The age of any particular intrusive mass is determined by its relations to other igneous rocks, and to sediments of known age.

During the Cretaceous much of the area was under the sea and received a deposit of conglomerate and sandstone, which has since been uplifted and largely eroded. An area of Cretaceous sediments, located in the northeast corner of T. 44 N., R. 8 W., now stands at an elevation of 4600 feet above sea level.

After this uplift, which followed the period of Cretaceous deposition, the region remained dry land until the present time, with the exception of small areas where continental sedimentation was going on during the Tertiary and later. (Possibly beneath the lavas to the east there may be more extensive lake deposits than we now realize.) The extensive volcanic activity, responsible for the eastern part of the quadrangle being covered with lavas, took place during the Tertiary, Quaternary, and recent periods. Evidence of glaciation, in the form of remnants of moraines and glacial lakes, is fairly abundant at the higher elevations in the southwestern part of the quadrangle.

AREAL GEOLOGY

The areal geology shown on the accompanying map represents the results of field work, which was done a number of years ago by members of the geological department of the Southern Pacific Railroad

Company. Through the courtesy of Mr. J. A. Taff, consulting geologist, and Mr. G. J. Sielaff, chief geologist of the company, material for the map was secured for use in publication. The contribution was primarily intended for the new state geologic map now in preparation by the Geologic Branch of the Division of Mines. In order not to delay the publication of the Shasta quadrangle until the state map is completed, it was thought worthy of appearing separately.

The original work was done on individual township plats (scale, one mile equals two inches). To combine the work satisfactorily on a much smaller scale (four miles equals one inch), some generalizations were made, such as the grouping of the greenstone and the Copley meta-andesite into one unit. Though the contacts have not been altered on the original plats, the legend has been revised in accord with present geological nomenclature.

The economic geology, location of mineral deposits, and descriptive matter are all the work of the writer, who has also done much in the way of general checking of the areal geology in the course of collecting the information necessary for the descriptions of formations.

The writer wishes to acknowledge the assistance of Olaf P. Jenkins, Chief Geologist of the California Division of Mines, who spent several days with the writer in a study of the geology along the Klamath River. He has also been very helpful in the preparation of the map showing areal geology and in editing the report. Dr. N. E. A. Hinds of the University of California, who is working on a detailed report of the geology of the Weaverville quadrangle, has also offered many helpful suggestions. Dr. F. M. Anderson, of the California Academy of Sciences, has very kindly contributed a description of the Cretaceous (Chico) rocks found in the Shasta quadrangle.

DESCRIPTIVE GEOLOGY

Metamorphic Sedimentary Rocks

Abrams Schist

The Abrams schist is typically a gray schist with a bright silvery sheen due to the mica content. Some of it will cleave into small pieces as thin as paper, which have considerable flexibility. This phase is seen at the north end of Horse Creek bridge across the Klamath. As one goes east from here the properties are found to vary, the schist becoming harder, darker in color and less readily cleavable. Quartz lenses, most of them small, but some with a width of six feet, are common. In thin section, under the microscope, the schist is found to be composed of alternating layers of finely crystalline quartz and nearly colorless mica.

It breaks down into gray soils that are full of mica flakes and very slippery when wet. In the extreme northwest corner of the quadrangle, and still further to the west along Elliott Creek, a green variety of this schist, apparently chloritic, was noted.

Hershey[8] gave to the formation the name, Abrams schist. It was used by Southern Pacific geologists, and is here retained. The formation is well exposed on Bully Choop Mountain southwest of Redding

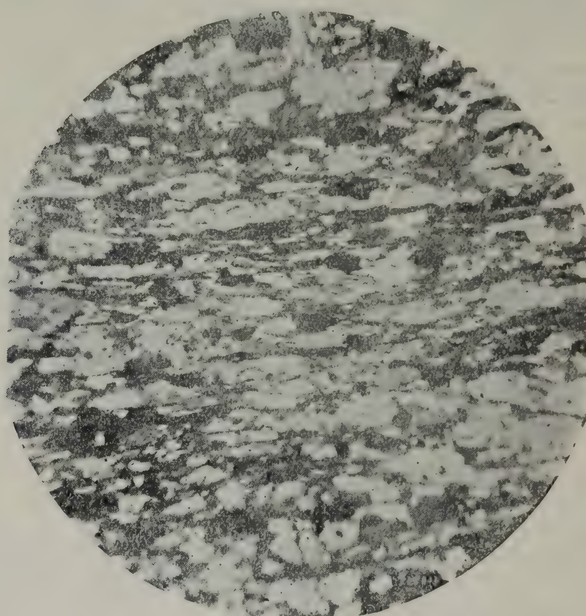
[8] Hershey, O. H., Am. Geol., Vol. 27, p. 227.
Hershey, O. H., Am. Jour. Sci., Vol. 184, pp. 263-273.

and along Trinity River near Douglas City. In the Shasta quadrangle it occupies quite an area in the northwest corner; and beyond the limits of the quadrangle it extends for many miles to the west and for some distance to the north. Diller[9] considers this schist pre-Devonian and probably older than the Silurian. No new evidence regarding its age, however, has been found during the present survey. It is undoubtedly the oldest formation in the quadrangle.

Sedimentary Rocks

Early Paleozoic and possibly Pre-Paleozoic Sediments and Schists.

This formation, or group of formations, includes a variety of shales, slates, cherts, limestones and schists. The age of the limestone lens, four miles west of Gazelle, has been definitely determined as Devonian[10]; and cup-corals and other fossils are abundant in it. Some shale



Photomicrograph of thin section. Nicols crossed. Enlarged 25 diameters. Abrams schist from Quartz Hill mine. The thin crystals of mica, seen on edge, are at the extinction position (dark). Most of the other material in the field is quartz.

associated with this limestone is not metamorphosed. To the southwest, along the road from Gazelle to Callahan, the series consists of light-colored to black shales and slates, some chert largely recrystallized by quartz, calcareous sandstones, and impure limestones. An occasional intrusive sill or dike occurs in the formation. Along Moffatt Creek, which runs north nearly through the center of the large area mapped under this heading to the west of Gazelle, also on the east side of the divide on which this creek rises, the rock is predominantly of light-green color and slaty appearance, with subordinate laminae of white quartz, ranging from a fraction of an inch to one inch wide.

[9] Diller, J. S., U. S. Geol. Survey, Redding Folio, No. 138, p. 10, 1906.
[10] Diller, J. S., and Schuchert, Chas., Amer. Geol., Vol. XIV, p. 30, 1894.

The quartz is more prominent as a residual remnant in the soil than is the formational rock, because of the difference in resistance to weathering of the two kinds of material. Folding and bending are prominent, resulting in varying directions of the strikes, and causing dips to range from flat to steep. The green color is probably due to the development of chlorite.

East of Yreka, and on the road to Ager, there are prominent exposures of massive white, apparently quite pure, quartz. It has the appearance of fine-grained quartzite; but it may have been developed from chert. In a quarry just southeast of Yreka, this white quartz alternates in bands several feet wide with siliceous appearing slates or schists of dark color. The Cretaceous conglomerate that overlies this older formation a little farther to the east, is largely made up of pebbles of quartz.

Along Klamath River, rocks mapped under this heading include a great variety of metamorphic material, argillites, phyllites, quartzitic slates, graphitic slaty schists, very fine-grained black schists, quartzites, talcose schists, pyroxene-hornblende schists, limestone and marble. These rocks are much more metamorphosed than those containing the Devonian fossils west of Gazelle, and have the appearance of much greater age. Specimens of many of these rocks were collected for petrographic study. The results of this examination, together with a detailed map, will be presented in another report.

Recent work[11] has indicated that the limestones in which Devonian fossils are found, and the associated sediments, probably belong to the Kennett formation mapped by Diller in the Redding quadrangle. Because some of the schists and other rocks included in the map unit may be older than the Kennett formation (Middle Devonian) just mentioned, the name 'Early Paleozoic and pre-Paleozoic' has been used on the accompanying map. It may also include some later Carboniferous beds.

Carboniferous (Mississippian)

Bragdon Formation

The Bragdon formation occurs very extensively to the south in the Redding quadrangle, where it has been mapped by Diller.[12] The following description is quoted from him.

"The Bragdon formation, named by Mr. O. H. Hershey (Amer. Geol., vol. 27, p. 238), is composed chiefly of thin-bedded, inter-stratified shale, sandstone, and conglomerate. The shale is dark, often black, in beds ranging from a few inches to 60 feet in thickness. The sandstone is generally less than 2 feet in thickness and rarely over 10 feet. It is for the most part gray and normal in composition, although sometimes dark, hard, and flinty, like some forms of quartzite, and in places decidedly tuffaceous.

The conglomerate constitutes the most characteristic part of the formation. It is generally composed in large part of black and gray pebbles of cherty quartz with others of sandstone, shale, and limestone derived from the Kennet formation. The limestone pebbles disappear by weathering, leaving holes in the surface, which give to the conglomerate a peculiar porous aspect. The beds of conglomerate are usually less than 10 feet in thickness, but sometimes attain a maximum of nearly 50 feet. Quartz and chert pebbles prevail in the smaller and finer beds, and sometimes also in the larger beds, where the pebbles are not over an inch in diameter. As the beds become coarser pebbles of sandstone become most abundant, while those of limestone also generally increase in number and size. Conglomerate extends throughout the area of the Bragdon formation, but appears most abundantly along

[11] Stauffer, Clinton R., The Devonian of California: Univ. Cal. Publ. Geol. Sci., Vol. 19, no. 4, pp. 81–118, 1930.

[12] Diller, J. S., U. S. Geological Survey, Folio 138, p. 3.

the Little Sacramento. Much of it along the river is fine, but some is coarse—with one exception much coarser than that found elsewhere. A short distance above Elmore, on the left bank of the river, some of the smooth, round cobbles of sandstone in a bed of conglomerate attain a maximum of 2 feet in diameter, though they are generally not over 6 inches."

Areas of the Bragdon formation shown in the southern part of the Shasta quadrangle are extensions of this larger area from the south. Where observed during the present survey, the formation is made up largely of dark-colored, in places nearly black, shales and slates with associated limestone lenses.

An interesting occurrence (not shown on the map) of thoroughly cemented siliceous conglomerate, which may belong to the Bragdon formation, was observed a mile to the west of the limestone quarry, located four miles southwest of Gazelle. The conglomerate answers Diller's description above, of the conglomerate along Little Sacramento River in the vicinity of Elmore, where it has been examined by the writer. In the part of the Shasta quadrangle just mentioned, the formation is composed almost entirely of quartz and chert pebbles, with average diameter of one-half inch or less. The holes attributed to the weathering out of limestone pebbles are lacking. The appearance of this conglomerate suggests the Bragdon; but somewhat similar conglomerates are found in the Chico (Cretaceous).

Triassic and Jurassic

Triassic strata are known to occur in the southeastern corner of the quadrangle[13] along Squaw Creek between McCloud River and the Great Bend of Pit River. This is an extension of an area mapped by Diller in the Redding quadrangle. In the extreme southeastern corner of the quadrangle is an exposure of Jurassic strata, which is also an extension of a larger area to the south and east.

In this southeastern corner of the quadrangle is an area of 250 square miles containing the Triassic and Jurassic strata mentioned above, also Carboniferous and Devonian, intricately intruded by several varieties of igneous rock. The country is extremely rugged, with the exception of 20 or 30 miles of road, is accessible by trail only. A heavy cover of soil with dense brush and timber adds to the difficulty of travel. The geology of this 250 square miles has not yet been worked out in any detail; and it will probably require a well equipped party to accomplish it.

Upper Cretaceous

Chico Formation

The Chico formation is composed chiefly of yellowish brown and gray sandstones, with conglomerate below and gray shale above. The only large mass of this formation in the quadrangle extends from south of Hornbrook into Oregon. Smaller patches occur in the vicinity of Yreka. To the south, in the Redding quadrangle, the Chico is of about the same relative importance as in the Shasta quadrangle; but further south, particularly along the coast, it occupies very large areas.

On the state highway, four miles north of the bridge across the Klamath, where Shasta River flows into it, the Chico conglomerate is

[13] Diller, J. S., Am. Jour. Sci., Vol. 165, pp. 342–363, 1903.

seen resting on an old eroded, oxidized surface of the greenstone. In the Cretaceous are abundant pebbles, two inches in diameter, derived from the greenstone. Northeast of Yreka, very abundant chert and quartz pebbles are found in the conglomerate; while west of Hornbrook, near the Hazel mine, cobbles of various igneous rocks, andesites, diorites, etc., make up the bulk of the conglomerate.

The following more detailed description of the Chico formation has been prepared especially for this report by Dr. F. M. Anderson, of the California Academy of Sciences, Golden Gate Park, San Francisco, who is making a special study of Cretaceous geology and paleontology in California.

Upper Cretaceous (Chico) Deposits in Siskiyou County, California

Prepared by F. M. Anderson, January 8, 1931

In 1895 J. S. Diller[14] called attention to the fact that during Cretaceous time the Klamath mountains in northwestern California and southern Oregon, including the Siskiyou and Trinity ranges, constituted an island area, along the eastern borders of which the sea formed straits, extending from the head of the present Sacramento Valley, by way of Shasta Valley, Siskiyou County, to the Rogue River Valley in Oregon.

In Siskiyou County there are various notable areas of later Cretaceous deposits which show the position of these straits, the largest of which extends in a broad zone from near Montague northward by way of Ager, Klamath River, Hornbrook and the valley of the Cottonwood to the summit of the Siskiyou mountains, and beyond.

In 1895 F. M. Anderson published an account[15] of these deposits in the Rogue River Valley, Oregon, extending from the Siskiyou summit northward by way of Jacksonville, to and beyond Rogue River.

Earlier mention of these deposits had been made by W. M. Gabb, in 1864, but no detailed description of them was given.

On the south flank of the Siskiyou mountains these upper Cretaceous deposits, consisting of thick and thin-bedded sandstones and overlying shales, have an aggregate thickness of more than 3000 feet, and fill the bottom and flanks of the Cottonwood Valley. They have a steep dip (30°) to the eastward, and along their eastern margin they pass beneath the later volcanic tuffs and lava flows both north and south of Klamath River.

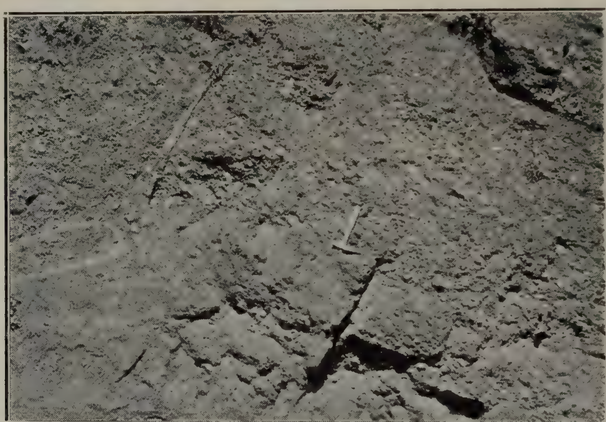
Other scattered and isolated areas of upper Cretaceous sandstone are found south of Klamath River, as on all flanks of Black Butte, about Willow Creek, southeast of Yreka, south of Grenada, and to the mountain southwest of Yreka at an altitude of near 4000 feet. In the Shasta Valley, southeast of Montague, are one or more isolated areas of these sandstones which have been broken through and partly overflowed by andesitic lavas.

[14] Diller, J. S., Tertiary revolution in the topography of the Pacific Coast: U. S. Geol. Survey, 14th Ann. Rept., Part II, pp. 399–434, 1894.
[15] Anderson, F. M., The physiographic features of the Klamath Mountains: Jour. Geol. Vol. 10, pp. 144-159, 1902.

In nearly all places these upper Cretaceous beds are found resting upon basement rocks of older periods such as constituted the land areas of this region during the Cretaceous period.

North of Klamath River, near Hornbrook, where these beds have their greatest thickness, their lower part consists of sandy strata having a total thickness of about 2000 feet. At the base they contain conglomerates; higher up, but below the middle of the sandy beds there are thin-bedded sandstones well filled with marine fossils, including many species of bivalves and gastropods; at the top the sandstones are overlaid by clay shales nearly 1000 feet in thickness, forming here the upper one-third of the Cretaceous sequence. In some places these shales contain sandy layers.

These Cretaceous beds are overlaid by tuffs and other volcanic rocks of great thickness of late Tertiary age, such as enter into the composition of the Cascade range to the eastward.



Cretaceous conglomerate containing greenstone pebbles in highway cut on Klamath River. Photo by O. P. Jenkins.

Two distinctive fossil-bearing zones occur in these upper Cretaceous beds, the lower of which, near the highway, in Rocky gulch and in the canyon west of Hornbrook contains numerous species of marine bivalves and gastropods, some of the more important of which, such as characterize the Chico group in many parts of California, are given in the following list from below the middle of the sandstones:

Triginia evansana Meek.
Chione varians Gabb.
Glycymeris veatchi Gabb.
Nemodon vancouverensis Meek.
Cucullaea decurtata Gabb.
Gyrodes expansa Gabb.
Actaeonella oviformis Gabb.
Alaria condoniana Anderson.
Cinulia obliqua Gabb.
Amauropsis oviformis Gabb.

At the junction of the uppermost sandstone beds and the overlying shales is the second notable zone of fossils, which contains few of those found in the lower zone, but instead a considerable variety of cephalopod forms, such as also characterize a higher horizon of the Chico

group in many parts of California. Some of the more important of them are the following:

Pachydiscus henleyensis And.
Barroisiceras knighteni And.
Prinonotropis klamathensis n. sp.
Placenticeras pacificum Smith
Placentic. californicum And.
Barroisic siskiyouensis And.

Cretaceous sandstone in highway cut, Klamath River, four miles north of highway bridge at Shasta River. Note: Hammer on fossiliferous bed. Photo by O. P. Jenkins.

On the Richardson ranch, north of Montague, were obtained the following species from a little lower horizon of the same zone:

Desmoceras klamathae n. sp.
Desmoceras yoloense n. sp.
Mortoniceras crenulatum And.
Phylloceras ramosum (Meek).
Pachydiscus siskiyouensis n. sp.
Puzosia hearni n. sp.

Both of the foregoing zones can be recognized in other parts of California, and their fossils permit their correlation with similar beds in other parts of the coast and in other counties. All of them are representatives of the middle and upper part of the Chico group of the California Cretaceous series.

As compared with the standard European time scale, the cephalopod horizons correspond to the upper Turonian and the lower Senonian divisions. The zone containing numerous bivalve and gastropod species, such as *Trigonia evansana* and *Actaeonella oviformis*, represent a position about the middle of the Turonian division.

The upper part of the Hornbrook section, consisting of clay shale, or sandy shale, may represent the upper beds of the Senonian division, although no fossils have been found here to confirm this view.

The two chief zones of the Hornbrook section appear in the same order in various parts of the State and of the Pacific coast.

In the section along Willow Creek, north of Montague, beds of lignitic coal have been found and have been prospected to a limited extent. They occur in the upper part of the group, and in the shales overlying the cephalopod zone mentioned above. These veins have been detected farther south in one or more wells, and they may be the source of gas which has been found in small amounts in parts of the Shasta Valley.

The conglomerates at the base of the section near Hornbrook are known to contain some gold, and have been prospected to a small extent in the past, but without satisfactory results. Considering the auriferous character of the basement formations in this region, it appears possible that in some places these conglomerates may have some economic importance.

Tertiary

Annual Report XIV of the United States Geological Survey shows on Plate XLV a small area of Neocene sediments to the east of the Chico formation, extending from the Oregon state line down to Klamath River and south for about an equal distance. The only part of this area examined during the present survey was that immediately adjacent to Klamath River. Except for a little conglomerate containing chunks of petrified wood, the rocks seemed to be for the most part of volcanic origin, tuffs and lavas.

Quaternary

Alluvial deposits and stream gravels of recent origin and a few small remnants of glacial moraines have been mapped under this heading.

Metamorphic Igneous Rocks

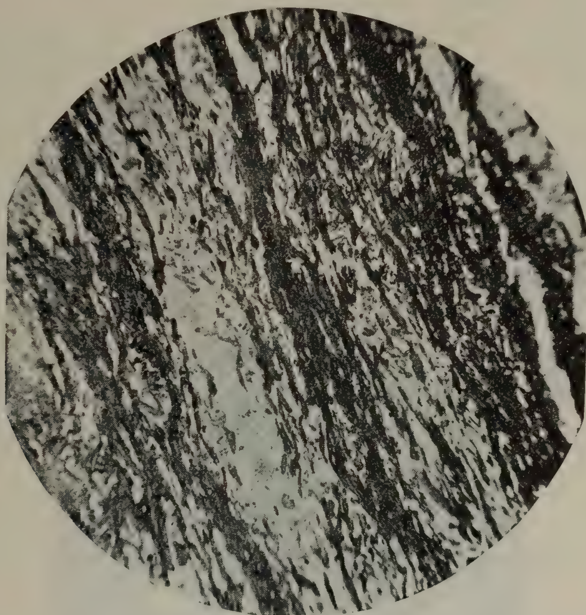
Salmon Schist

The Salmon schist is typically a hornblende schist. Dark-green hornblende makes up from 70% to 90% of the rock.[16] Quartz, lime-soda feldspar, minute plates of biotite altering to chlorite, small grains of epidote, magnetite and ilmenite are also present. The texture varies from fine to coarse. In the varieties of finest grain, the individual needles of hornblende are too small to be seen even with a lens; and the rock is of a dark-green color with a silky sheen. In the coarse-grained type, the color is usually a darker green; and the individual crystals of hornblende are easily distinguished with the naked eye. Apparently the Southern Pacific geologists included some other varieties of schist in mapping this formation. For instance, in the southwestern corner of the quadrangle, near the Dorleska mine, the schist appears to have been formed by the metamorphism of siliceous sediments.

The formation is not an important one in the Shasta quadrangle, except in the southwest corner; but to the south and southwest, it is

[16] Ferguson, H. G., U. S. Geol. Survey, Bull. 540, Part I, p. 21, 1913

found in rather large bodies. In the Weaverville and Big Bar quadrangles, where it has been studied in the field by the writer, quartz veins carrying gold have been mined in the hornblende schist.



Photomicrograph of thin section. Enlarged 25 diameters. Fine-grained hornblende schist from an exposure on McKinney Creek, 2.2 miles south of the Klamath River. The white bands are quartz. This small exposure is not shown on the map.

Greenstone and Copley Meta-andesite

The Copley meta-andesite was named by Diller [17] in the Redding quadrangle, where it is an important formation. He describes it as follows:

"The Copley meta-andesite was named from its occurrence in the vicinity of Copley, where the most important type is well exposed. It is generally pale green on weathered surface, but darker green and compact on fresh, somewhat shaly fracture. Distinct porphyritic structure is not common, but the rock is frequently more or less fragmental, a feature which shows most clearly on the weathered surface.

"Petrographic Description.—The Copley meta-andesite is well exposed along the river in the vicinity of Copley, where it is decidedly green and compact, though in places clearly fragmental. In thin section under a microscope it is found to be composed chiefly of plagioclase (apparently andesine) and chlorite with variable amounts of epidote, fibrous green hornblende, magnetite, and calcite, sometimes also quartz The plagioclase is most abundant, generally much altered, but sometimes fresh, in well-defined elongated crystals, with irregular patches of chlorite apparently derived from augite filling the spaces between them. Epidote is generally present and often abundant and varies inversely with the amount of calcite present. Magnetite is less abundent, in some places rare. The regular intersertal structure is often modified by the parallel, stream-like arrangement of the feldspars. The rock, though generally holocrystalline, is often hypocrystalline and ranges in structure from pilotaxitic and intersertal to granular in which only the feldspar shows traces of crystallographic boundaries.

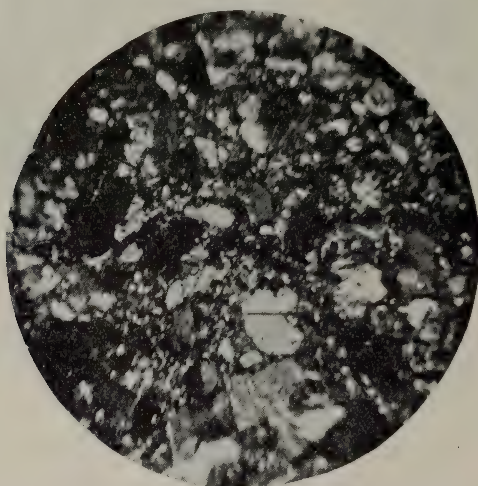
"Originally the rock was some form of pyroxene andesite, but in view of the degree of alteration it may be more appropriately designated meta-andesite."

[17] Diller, J. S., U. S. Geological Survey, Redding Folio, No. 138, p. 6.

Under 'Occurrence,' he describes it as a great mass of lava made up of many separate flows of considerable variety, sheets of tuffs, amygdaloidal phases, and a meta-andesite breccia. He finds that the rocks of the Kennett formation overlie the meta-andesite, and hence that it is older than the middle Devonian.

In the Shasta quadrangle, on the original maps of the Southern Pacific Company, a distinction was made between the Copley meta-andesite and a rock called 'greenstone.' In the belief that these both belong to the same ancient volcanic series, they have been combined on the accompanying map. Another reason for combining them is the extreme difficulty of separating the many varieties of ancient volcanic material into different formations on any criterion that can be used in the field.

A few small masses of the Copley meta-andesite near the center of the south boundary of the Shasta quadrangle may be regarded as



Photomicrograph of thin section. Nicols crossed. Enlarged 25 diameters. Copley meta-andesite or greenstone, showing fragmental character, Klamath River near confluence of Shasta River.

extensions of areas mapped by Diller [18] in the Redding and Weaverville quadrangles. Larger masses are exposed in the northwestern part of the Shasta quadrangle from a point a little west of Yreka nearly to the western boundary. McAdams Creek flows westerly, then south, near the center of the exposure. From Yreka the mass of greenstone and Copley meta-andesite also extends north for many miles; and Klamath River cuts through it.

Along McAdams Creek we find a coarse greenstone breccia with individual fragments about two inches in diameter. The angular fragments differ enough in grain size and color or shade, so that their outlines are readily observed. Various shades of green and brown, due to oxidation of the iron, predominate. Another variety of the

[18] Diller, J. S., *op. cit.,* also U. S. Geological Survey, Bull. 540A, plate 2.

breccia, with fragments only about a quarter of an inch in diameter, is found here; also some very fine-grained material, apparently flow-banded, with alternating bands of light and dark green, one or two inches wide. Some of the greenstone is amygdaloidal; and on weathered surfaces the amygdules have been dissolved out, the result being a vesicular appearing rock. That is, the surface is full of small round or oval holes, which were at one time gas bubbles in the lava. The breccia and amygdaloidal varieties are found also at the Cherry Hill and Mount Vernon mines on either side of the divide on which McAdams Creek rises. A specimen taken from the lowest tunnel of the Mount Vernon is a tough, compact, fine-grained, green rock composed of angular fragments in shades of green and brown, an inch in diameter, in a matrix of smaller fragments grading down in size to very fine material. Examination under the microscope shows that enough of the feldspars remain in some of the fragments for identification as andesine, showing that the rock is an andesite. Alteration of the other fragments is advanced, as is that of the ground-mass and all of the fine-grained parts. A more detailed study of the alteration was made in connection with the work done along the Klamath River; and description of the types found there is being prepared for a later report. The tough green rock, which appears to be of fairly uniform fine grain along the river, proved to be a consolidated pyroxene-andesite tuff in all stages of alteration. Development of epidote, chlorite, and serpentine, and introduction of silica (quartz), calcite, and sulphides of iron have all had a part in this alteration.

Igneous Rocks

Serpentine and Peridotite

The serpentine and peridotite appear as masses of rock of a light-green color on weathered surfaces, with stains of yellowish-brown and reddish-brown due to oxides of iron. Where the alteration to serpentine is complete, typical greasy green color in light and dark shades are present. The fresh fracture of the least altered rock is nearly black in color and of fine grain. Derived soils vary from a yellowish-brown to a reddish-brown. The rocks are apparently older than the granodiorite of Castle Crags; and contact relations are given in the description of the latter formation. The serpentine and the gabbro are even more intimately intermingled than the map indicates; and that they are closely related in origin seems probable.

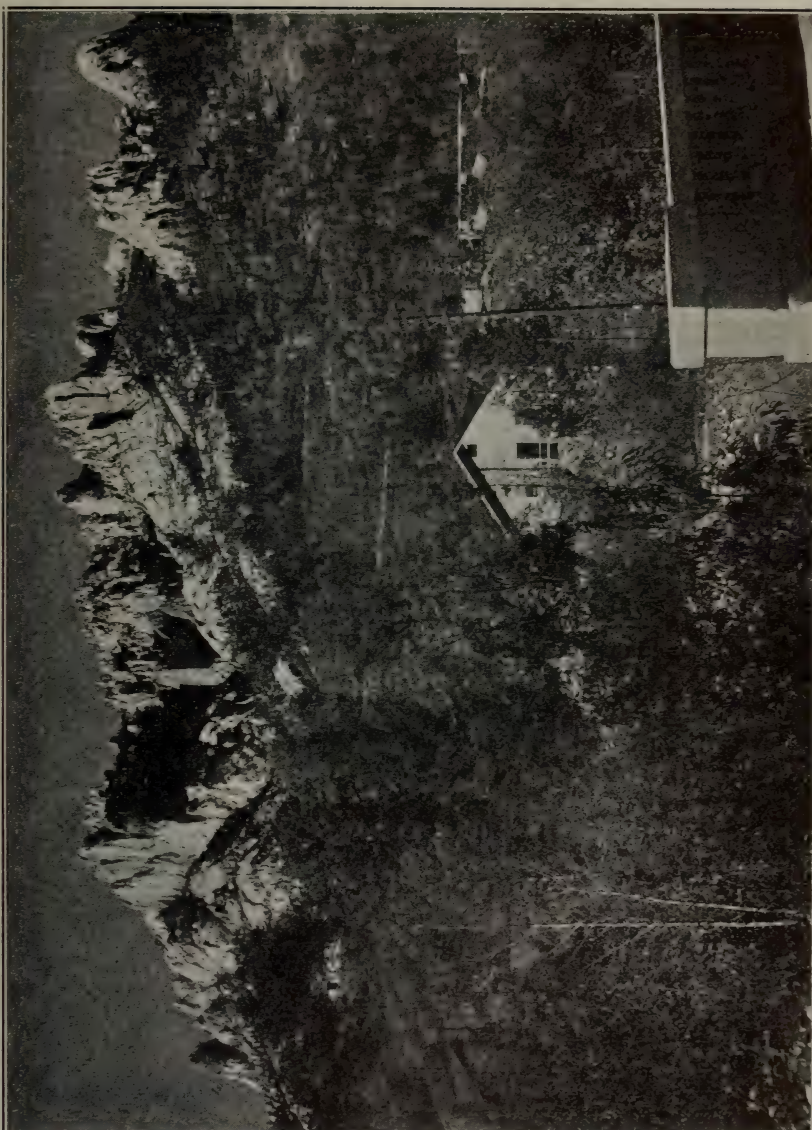
The serpentine and peridotite with associated gabbro are seen in very large masses over wide areas in the southwestern quarter of the quadrangle. Also important occurrences of the serpentine are found in the vicinity of Klamath River. On the north bank of the Klamath, at a point a quarter of a mile east of Horse Creek bridge, is a good exposure of a contact, showing the serpentine intruding the Abrams schist. The serpentine is also intrusive into the other schist series referred to in this report as Paleozoic or pre-Paleozoic. Dikes of the serpentine in this schist were observed near the north end of the highway bridge where it crosses Klamath River near Dogget Creek, and elsewhere in this vicinity.

Gabbro

The gabbro is an important formation throughout the southwest quarter of the quadrangle, where it is intimately associated with the serpentine. In texture, it is of granitic grain, with grain size varying from about $\frac{1}{8}$ to $\frac{1}{2}$ inch. The dark-colored ferromagnesian minerals slightly predominate over the white feldspar in the typical rock. However, much variation in this regard was noted, some small exposures showing only ferromagnesian minerals and no feldspar.

Specimens for study were collected near the Strode mine, the Lost Horse prospect, and from Scorpion Creek about a quarter of a mile from Trinity River, in Sec. 5, T. 37 N., R. 7 W. The specimen last mentioned proved to be the least altered. The grain size varies from $\frac{1}{8}$ to $\frac{1}{4}$ inch; and the dark-green ferromagnesian minerals are more abundant than the white feldspar. Under the microscope, the feldspar was found to be a basic labradorite, which has started to alter to a porcelain-like mass, white in reflected light and very cloudy in transmitted light, in which zoisite can be recognized. The ferromagnesian mineral is probably augite. None of the minerals show color in thin section except a few small spots of light-green alteration products. A few small grains of olivine were noted. Crystals are mutually interfering; and practically no crystal faces are developed. A few small crystals of feldspar are included in some of the pyroxene crystals.

The specimen taken from a tunnel at the Strode mine, in which assessment work was being done, proved to be highly altered. The feldspar crystals are completely altered; and only a few small remnants of the augite crystals remain, the balance being altered to chlorite and serpentine. Silicification has also affected this rock, the specimen showing 5% or 10% secondary quartz. Microscopic vienlets of serpentine traverse the rock, which fractures on these. Thus when the rock is broken an exaggerated idea of the serpentine content is obtained. This specimen has an average grain size of about $\frac{1}{16}$ inch. The specimen from the Lost Horse tunnel is also highly altered; but is not silicified. The ferromagnesian minerals have been bleached out; and the color of the rock is light-green. Remnants on which optical properties could be measured proved to be augite of the variety diallage. Most of it is altered to serpentine; and the feldspar is altered as described above.



Castle Crags from Castella. Photo by courtesy Redding Chamber of Commerce.

Granodiorite (and Diorite)

On the original Southern Pacific maps, a distinction was made between granodiorite and diorite. In the southern half of the quadrangle practically all areas under this heading were shown as granodiorite; while in the northern half a few areas of diorite were shown in addition to the granodiorite. These formations are combined under a common conventional sign on the accompanying map; and the letters 'di' are used to show in a general way what was mapped by the Southern Pacific geologists as diorite. All exposures examined during the present survey proved to be granodiorite or at least quartz diorite.

Photomicrograph of thin section. Nicols crossed. Enlarged 25 diameters. Granodiorite from Gilfeather prospect. One small crystal of microline (lattice-structure) is seen to the right of center. Other minerals are plagioclase (albite twinning striations), quartz (irregular clear areas), and biotite.

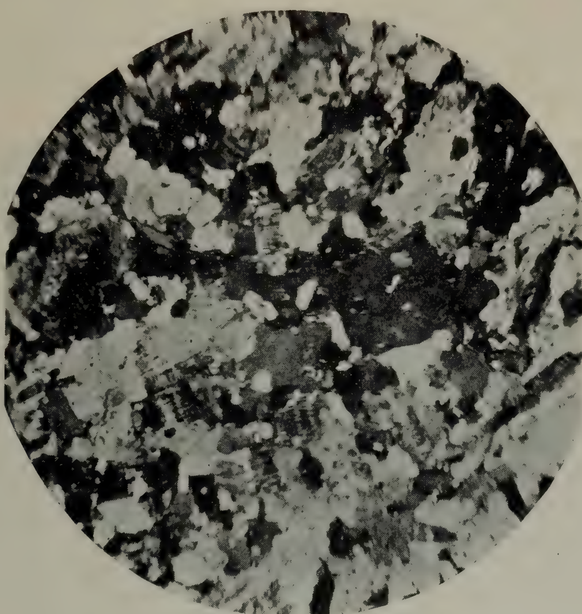
Much variation in the quartz content was observed; but diorite without quartz was not found. Detailed descriptions of some of the occurrences follow.

To the west of the point on the railroad, marked Castle Crag on the accompanying map, are the Castle Crags proper, a mass of granitic rock rising to elevations of more than 6000 feet, or 4000 feet above Sacramento River, which is only about two miles away from some of the higher peaks. Erosion, in part glacial, has carved the rock into domes and pinnacles with vertical walls hundreds of feet high. An imposing view of these peaks is obtained from points on the State highway a few miles to the south; and they make quite a prominent landmark.

The rock is of coarse granitic grain, and nearly white in general appearance where unstained. Light-pink crystals of untwinned feldspar, $\frac{1}{4}$ to $\frac{1}{2}$ inch long, with maximum lengths of more than an inch, are

seen in an aggregate of smaller grain size, composed of white feldspars with albite striations and fairly abundant colorless quartz. Less abundant are flakes of brown biotite, and prisms of green hornblende less than $\frac{1}{8}$ inch long. The large pink feldspars are speckled with minute included crystals probably of biotite and magnetite. Small crystals of an earlier generation of feldspar also seem to be included. Dikes, several feet wide, of similar appearance, but finer grain ($\frac{1}{8}$ inch), cut through the coarser rock as do quartz stringers an inch or two wide.

These crags, where examined at the highest points accessible from the east side, and on the west side on the north fork of Castle Creek, were



Photomicrograph of thin section. Nicols crossed. Enlarged 25 diameters. Granodiorite from Gilfeather prospect. Several small crystals of microcline (lattice-structure) show in this section. The amount of quartz (clear, irregular patches) in this section is greater than normal for this vicinity. The specimen was taken near a small quartz vein.

found to exhibit enough different varieties of crystallization to afford material for an extended petrographic study alone. This study could be still further expanded to include contact phases of the more basic series. No satisfactory slide for study of this rock under the microscope was available. Such work as was done indicates that the pink feldspar is orthoclase, but that plagioclase predominates. There is also considerable quartz. The rock is a granodiorite, and is the most acidic rock seen in the quadrangle.

In the field, it was observed that angular and corroded inclusions of a dark-green rock are scattered sparsely throughout the mass of the granodiorite. They appear to have come from the peridotite, although they may have been derived from the Copley meta-andesite. However,

the chilling of the mass of granodiorite near the contact with the peridotite (as shown by the finer grain), the recrystallization of the peridotite, and the baking of the latter (evidenced by prominent areas of brick-red soil), all indicate that the granodiorite is intrusive into the more basic rocks.

A fresh specimen was obtained from the lowest tunnel of the Golden Jubilee mine (No. 12 on map) in the southern part of the quadrangle northwest of Carrville. This is quite different in appearance from the Castle Crags variety. In the hand specimen it is seen to be of granitic grain, with average size of crystals of about $\frac{1}{8}$ inch. Light-colored minerals predominate; but the rock is so plentifully sprinkled with crystals of hornblende and biotite that, at first glance, the dark minerals seem nearly equal in quantity to the light. Under the microscope the rock is found to be composed of the following minerals: (roughly estimated) 50% albite and oligoclase, with the latter much the more abundant,

Castle Crags from the west side.

30% quartz, 10% green hornblende, and 10% brown biotite, with accessory magnetite and apatite. The feldspar and hornblende have well-developed crystal faces; while the quartz occurs interstitially in patches with irregular extinction. This rock is also a granodiorite, but approaches a quartz diorite.

Still less acidic types were studied from the Gilfeather prospect (No. 8 on map) and the Commodore mine (No. 4 on map) in the northern part of the quadrangle. Brown biotite is very prominent in the rock from the Gilfeather, and hornblende and biotite altering to green chlorite in that from the Commodore. Quartz is not prominent in either hand specimen; but in thin section it is seen to constitute at least 15% of the rock. Part of that in the Commodore specimen is secondary, due to silicification. Microcline was found in both; while plagioclase is much the most abundant mineral. In the Gilfeather specimen this was found to vary from near albite to a basic andesine in the same crystal with zonal extinction. Both occurrences are granodiorite.

Andesite, Diorite Porphyry and Dacite.

Under the above field names, which give a good idea of the actual composition, several varieties of dikes and small intrusive masses have been generalized. These small intrusions are more numerous than is indicated on the accompanying map; and many of them are too small to show on this scale. The results of a study made during the present survey of a few of them are given as follows:

From Sec. 21, T. 38 N., R. 8 W., one mile northeast of the Seymour Placer Gold Mines camp on the east fork of Coffee Creek, a specimen was taken from the top of the ridge, elevation about 6000 feet. This came from a small intrusion into the serpentine; and a fused contact with the latter was seen, with inclusions of the serpentine in the intrusive rock up to ½ inch in diameter. In the hand specimen this intrusive is a rather dark greenish-gray holocrystalline rock with a fairly uniform grain size between 1/32 and 1/16 inch. With a lens it appears to be made up of feldspar and green hornblende in about equal amounts. Under the microscope the feldspar is seen to be an andesine-labradorite, with abundant pericline twining. The feldspars are strained, as shown by irregular extinction; and some are bent. Some of the hornblende crystals are bent and also broken. The rock is a spessartite, a lamprophyre of the composition of a basic diorite. Unfortunately, however, the name, spessartite, is used not only for a rock of this kind, but also for a variety of the mineral garnet.

From a dike in the serpentine, about half a mile up the east fork of Coffee Creek from the Seymour camp, another specimen was taken. In hand specimen it is a holocrystalline porphyry with white feldspar phenocrysts, ⅛ inch long, and dark green hornblende crystals of a maximum length of ¼ inch making up about 20% of the rock. The ground-mass is fine-grained, crystalline, and dark greenish-gray in color. Under the microscope the feldspar (andesine) and hornblende phenocrysts are seen to be in a groundmass made up largely of hornblende needles, with interstitial andesine. The large feldspars are highly altered; and the hornblende phenocrysts are corroded, bent and broken. Microscopic inclusions made up entirely of mats of hornblende needles suggest that fragments of the serpentine or peridotite have been picked up and recrystallized. The rock is a diorite porphyry. The straining of the minerals in these two rocks last described indicates that they have been subjected to considerable pressure, and hence are probably older than the last uplift of the mountains.

The area of several square miles in T. 45 N., R. 8 W., marked 'an' on the accompanying map, was called Triassic andesite porphyry on the original maps of the Southern Pacific geologists, as were the two smaller areas a mile to the north and three miles to the southwest. Here they have been included under the general field name of andesite; although the rock differs somewhat from normal andesite. This formation was examined at the Eliza mine (No. 7 on the map) on the north edge of the largest mass, and on the high ridge to the south between the Eliza and Schroeder mines. Most of this is a fine-grained dark greenish-gray rock much resembling the greenstone; but here and there patches occur that contain large feldspar phenocrysts, ¼ inch long, scattered through a finely-crystalline groundmass, in which laths of feldspar are

distinguishable with a lens. Under the microscope this porphyritic variety is found to consist of albite phenocrysts in a groundmass of albite-oligoclase, hornblende, and biotite, with accessory magnetite. The rock is a camptonite similar in composition to the variety of finer grain described below; but it contains more magnetite and less biotite. Peculiar corroded inclusions less than $\frac{1}{32}$ inch in diameter are composed entirely of minute flakes of biotite with a matted appearance.

The rock of finer grain, obtained from the lowest tunnel of the Eliza mine, is a dark greenish-gray in color. The grain is so fine, and the alteration has proceeded to such an extent, that it is difficult to recognize individual minerals in the hand specimen. With a lens, altered, dark-green hornblende needles are seen, and possibly remnants of altered feldspars. Green serpentine is found on the fracture planes. Under the microscope the rock is seen to be holocrystalline porphyritic with phenocrysts of hornblende (the larger) and feldspar (albite-oligoclase) in a groundmass of similar material, grading in size down to very small crystals. Among these smaller crystals, biotite is also abundant in minute brown flakes. Magnetite is an important accessory mineral. The larger hornblende crystals are bent and broken; and many of them are altering to chlorite and serpentine. Some include smaller crystals of feldspar. The large optic angle of the hornblende indicates a high soda content[19], which is in keeping with the composition of the feldspars. The rock is a camptonite rich in soda, that is, a lamprophyre of about the composition of diorite or andesite.

Descriptions of other dike rocks will be found under the names of individual mines such as the Cherry Hill, Commodore, Dorleska, Golden Jubilee, Mount Vernon and Yellow Rose, where the dikes and the ore deposits are associated. Close association of veins and dikes was noted in mines and prospects in all parts of the quadrangle examined.

Tertiary and Quaternary Lavas

A reference has already been given (p. 5) to Diller's work on the lavas of Mt. Shasta. Other lavas, which cover much of the eastern half of the Shasta quadrangle, have not yet been studied to any great extent. As a matter of general interest, Diller's [20] description of the Quaternary pyroxene andesite, which flowed from Mt. Shasta down Sacramento River for 50 miles, is here given. The river has since cut through the lava and into the older rocks under it for about 50 feet.

"The upper surface of this long flow of pyroxene-andesite is generally somewhat vesicular and in many places decidedly porphyritic, with numerous small crystals of plagioclase, chiefly andesine, embedded in a dark gray groundmass which the microscope discovers to be made up chiefly of small crystals of plagioclase and grains of pyroxene, with a few of olivine and considerable globulitic base. This andesite is decidedly basaltic.

"There are a few small square sections of unstriated feldspar, probably orthoclase. The pyroxene is partly automorphic. Its parallel extinction and faint pleochroism indicate that it is probably bronzite."

A single specimen examined during the present survey from an exposure near Hazel Creek proved to be even more basaltic than that described by Diller. The specimen is distinctly porphyritic; and both phenocrysts and microlites in the groundmass are basic labradorite.

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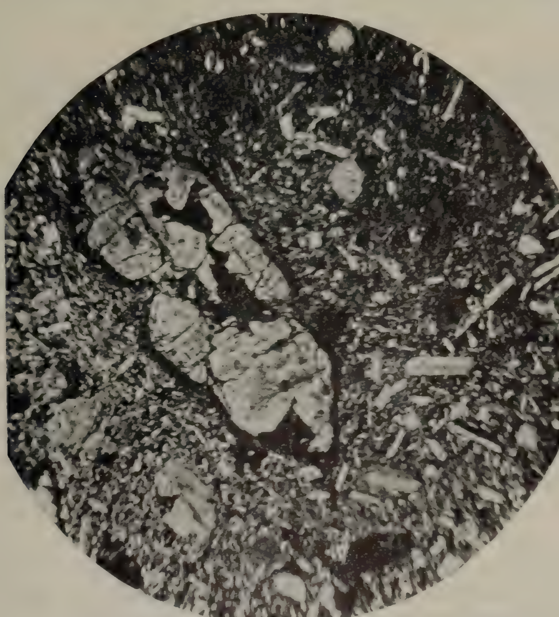
[19] Winchell, N. H. & A. N., Elements of Optical Mineralogy, Vol. II, chart, p. 214.
[20] Diller, J. S., U. S. Geological Survey, Redding Folio, No. 138, p. 9.

The pyroxene gives a large angle of extinction instead of the parallel extinction mentioned above.

Columnar basalt on Klamath River, Sec. 35, T. 48 N., R. 5 W.

Other basaltic types were noted on Klamath River in the eastern part of the quadrangle. A fine exposure of basaltic rock with columnar structure was observed in a railroad cut in Sec. 35, T. 48 N., R. 5 W.



Photomicrograph of thin section. Nicols crossed, Enlarged 25 diameters. Basaltic rock, Klamath River, Sec. 33, T. 48 N., R. 5 W. Iron oxides weathered from the olivine give the remnants of the large crystals a distinctly red color, particularly on weathered surfaces.

ECONOMIC GEOLOGY

Asbestos

Asbestos has been reported in past publications of this division near the Altoona quicksilver mine, in townships 37 and 38 north, ranges 4 and 5 west near Hazel Creek (Sims), on Mears Creek, also four miles west of Gazelle, and in Sec. 8, T. 41 N., R. 5 W. During the present survey an old prospect with amphibole asbestos on the dump was noted near the road from Castella to the Altoona quicksilver mine, a few miles east of the mine. The only active asbestos mine found in the quadrangle is the Jones, described below.

Bibl: State Mineralogists' Reports XXI, p. 421; XXII, p. 128.

Jones Brothers Asbestos Mine (No. 1 on map) is operated by the Jones Brothers Asbestos Supply Company, 370 Second St., San Francisco. Ed Jones is president and C. M. Plants is secretary. The mine is on leased railroad land in Sec. 7, T. 37 N., R. 7 W., a quarter of a mile west of the Coffee Creek bridge, where the main road from Carrville to the north crosses. At the time of visit about five men were at work sorting the chrysotile asbestos from irregular fractures in a dark-green, greasy-looking serpentine. The asbestos was being taken from an open cut, 8 by 20 feet and 7 feet deep. A 100-ft. prospect tunnel, a few feet below this cut, showed nothing but serpentine. The asbestos is a green chrysotile of apparently very good quality with considerable strength of fiber. The length varies from a quarter of an inch to two inches, with an average of three quarters of an inch. Two tons had been shipped; and five tons were sacked for shipment. The foreman stated that the asbestos shipped was valued at $380 per ton.

Barite

Glidden Barite Deposit, formerly *Loftus* (No. 2 on map). Glidden Company of California, 1300 Seventh Street, San Francisco, now owns the barite deposit, formerly called the Loftus Barytes Prospect, in Sec. 18 and 19, T. 38 N., R. 3 W. Three claims known as Barite No. 1, Barite No. 3, and Marion have been patented under Mineral Survey 5906. Land formerly belonging to the railroad has been purchased to take in another exposure 1500 feet to the southeast. The deposit is seven miles by trail from Castella; but at the time of visit a road was under construction to follow this trail in a general way at a grade of about 10 per cent. The plan is to start trucking the barite over this road in May, 1931. The deposit, at an elevation of nearly 5000 feet, is 3000 feet above the railroad tracks at Castella.

On the very top of the ridge, on the line between sections 18 and 19, the barite has been exposed over an area of several acres by numerous long cuts, two feet deep, and two shafts 20 and 30 feet deep. Associated with the barite are limestone and a dark-gray slate, probably Carboniferous or Devonian in age. A prominent limestone lens half a mile to the north strikes S. 10° W. and dips 23° east. Remnants of fossils were found in this; but nothing in a good state of preservation. Better material could no doubt be found by a careful search. Strata in the barite are marked by dark lines an inch or more apart, and lie nearly horizontal. The barite, stated by the operators to analyze 97

per cent barium sulphate, is of excellent quality except that it has a gray color that will not bleach out under acid treatment. In the manufacture of lithopone for white paint, the barite is calcined and then purified by dissolving and filtering, which eliminates the color.

Chromite

In 1918, the State Mining Bureau published a bulletin describing fully the chromium and manganese deposits of the State. On account of lower market prices, very little chromite has been mined since that time. Hence no attempt has been made to visit chromite deposits during the present survey. Bulletin 76, just mentioned, lists some 25 properties in Siskiyou County, many of which are within the Shasta quadrangle. Shipping points are Gazelle, Dunsmuir, Yreka, Hornbrook and Montague. A few additional properties are listed in State Mineralogist's Report XXI. It has been estimated that 30,000 tons of chromite can be shipped from Siskiyou County in a year if the market price is high enough to cover the expense of the long truck haul usually necessary.

During the present survey chromite deposits were observed near the road between Castella and the Altoona quicksilver mine, in the serpentine; also near the Forest Service road, which runs westerly into the mountains from a point on the state highway about four miles south of Sims (Hazel Creek). Some chromite remains in bunkers and on loading platforms at these properties; also at Gibson railroad siding, where a small crushing and screening plant for chromite was operated. A large lens of chromite has been mined from a locality on Little Castle Creek near Dunsmuir. Additional information will be found in the references listed below. Bulletin 76 and separate chapters of the reports of the State Mineralogist may be purchased at offices of this division.

Bibl: State Mineralogist's Reports XXI, p. 421; XXII, pp. 13 and 130. Bull. 76, pp. 181–203, 222–223, 209–212, 224.

Coal

Coal in the Chico (Cretaceous) formation is noted in a preceding section of this report by F. M. Anderson. Nothing has been done with this coal recently. Near the road from Ager to Yreka, at a point about five miles from Ager, there is a dump of black bone from one of the prospects; also a pile of clinkers apparently the result of the burning of the coal. The portal of an old slope exposing several feet of coal and bone, with hanging wall of very fine-grained sandstone is located near this dump. The strike is S. 40° E., and the dip 23° northeast. Further details on the development of this coal are given in the reference below, which mentions some diamond-drill holes that were put down to prospect for it.

Bibl: State Mineralogist's Report XXI, p. 425.

Copper

Copper is known to occur in substantial quantities in this region, but chiefly west of the northwest corner of the Shasta quadrangle at the

Blue Ledge and Gray Eagle mines. Both of these mines have good tonnage of ore blocked out; but they can not produce at the present low prices prevailing on account of the distance from smelters and railroad. Further details on these two mines will be found in the references given below.

'Copper croppings and gossan' are shown on a map made by the U. S. Forest Service on which C. J. Fry of Medford, Ore., mapped geology in 1912. Those in the Shasta quadrangle are shown in:

Township	*Range*
45 N.	9, 10 W.
46 N.	7, 8, 9, 10 W.
47 N.	7, 8, 9 W.
48 N.	9 W.

The map is called 'Portions of the Klamath and Smith River Watersheds in and adjacent to the Klamath National Forest'; and the original tracing is on file at the office of the U. S. Forest Service in Yreka. It shows a part of the northwest corner of the Shasta quadrangle and a larger area to the west and southwest, including Orleans. The croppings shown on this map in the locations given above have not been visited during the present survey.

Bibl: State Mineralogist's Report XXI, p. 427.

The following two properties came to the attention of the writer during the present survey:

Empire Mines, owned by G. E. Garfield and J. W. Wright of Etna, comprises five claims and a mill site, 10 miles from Callahan or 12 miles from Etna on French creek. The owners state that ore from an open cut, 8 by 30 ft. and 8 ft. deep, assays 9.7% copper, $0.33 per ton silver, and $36.37 per ton in gold. The vein is said to be 12 ft. wide of hard ore with no gossan. Ore, said to run $42 per ton in free gold, is now being put through a small stamp mill equipped with plates. There is also a small cyanide plant. The writer regrets that this property was brought to his attention too late in the season for a visit.

Isabella Copper Mine, owned by the Isabella Copper Co., c/o Loren W. Smith, Attorney at Law, 611 Bank of America Building, Oakland, California, is in Sec. 34, T. 41 N., R. 7 W., 18 miles southwest of Gazelle. Development consists of a tunnel, 330 ft. long, with a 6-ft. shaft at a point 178 ft. from the portal. The old steam-driven compressor mentioned in State Mineralogist's Report XXI, p. 429, is in bad condition. Nobody was at this property when it was visited; and the workings were not examined. The dump shows much white quartz, in which pyrite and chalcopyrite are seen, also a more plentiful gray mineral of metallic luster, probably tetrahedrite or gray copper.

Gems

Agates are found at a place called Agate Flat, 15 miles east of Hornbrook, by a road that turns from the Klamath River road near Low Wood school. George A. Greive, agate cutter, keeps a large number of these agates on display at Hornbrook. Agates have also

been reported from Willow creek near Ager by R. E. Macaulay of Dunsmuir; but the writer was unable to locate the place.

Gold (Lode)

Amalgamated, see *Gold and Nickel.*

Barundun Prospect, owned by Simon Barundun, Gazelle, and Orman Lutz, 5400 Hillen Drive, Oakland, California, comprises the SW. ¼ Sec. 17, T. 40 N., R. 7 W.; and is located 25 miles west of Gazelle over a fair road. In addition to the quarter section, a millsite in Sec. 18 is held. The property is developed by means of several tunnels, averaging about 300 ft. each in length, some of which have caved. The following are open, and were inspected. An upper tunnel cuts across black slates with flat dip, then turns and follows a vein for 20 feet. The dip of this is 60° to 70°, and the width 2 to 4 feet. At an elevation 120 ft. below, a second tunnel cuts across the slates; and here the dip is steeper. The vein has not yet been reached. A third tunnel at an elevation a little lower than the first and laterally several hundred feet distant goes through black slate. Near the face it cuts a steep vein from one to four feet wide, average width 2 ft.; and a drift has been driven 30 ft. on this. Barundun states that 116 tons of ore, which were run through an old two-stamp mill on the property, yielded $8 per ton in free gold, and that additional values occurred in the sulphides, which he was unable to save. Some ore from the property has been treated in an arrastra also.

Blue Jacket is an old prospect a quarter of a mile northwest of Carrville, which was described by MacDonald [21] in 1912. A sketch map shows a 2½-ft. vein of low-grade quartz cutting across granodiorite porphyry, aplite and serpentine, and if projected, into greenstone. Lamprophyre dikes are also present. Some mineralization (free gold) was found in the porphyry and aplite; and an attempt was made to develop this on a large-tonnage basis. No work of importance has been done here recently.

Blue Jay, 1¾ miles west of Carrville, is another old property described by MacDonald[22]. The country rock is serpentine cut by small masses of granodiorite porphyry, by lamprophyre dikes, and by a large dike of fine-grained, green meta-basalt. Rich pockets were found in fissures and sheer zones in the meta-basalt. A small pocket produced $60,000 in a few days in 1892; and a rush to the district resulted. Some years later more work was done on the property; but nothing has been done recently.

Bonanza King, the claims of which extend in a northwesterly direction from the East Fork of Trinity River, in Sec. 30, T. 37 N., R 6 W., for 4½ miles, has been an important gold producer, equipped with a 40-stamp mill and 1000-hp. hydro-electric plant. Some work was done here about 1928, by the United Trinity Mines. Recently the mine has been idle; and it was not visited.

Bibl: State Mineralogist's Report XXII, p. 25; U. S. G. S. Bull. 530–D, p. 36.

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[21] MacDonald, D. F. Notes on the gold lodes of the Carrville district, Trinity County, Cal. U. S. Geol. Survey, Bull. 530, Part I, p. 21, 1912.
[22] *Op. cit.*

Burner Mines, a group of four claims, described by MacDonald in 1912, is a mile north of the Golden Jubilee. The geology is similar to that of the Jubilee; but the veins are smaller with pockets at fissure and dike intersections. No important developments have been made here recently.

Carr's Iron Capped Dike,[23] a mineralized dike, a few hundred yards west of Carr's hotel at Carrville, has been prospected in the hope that a large tonnage of low-grade ore might be developed. It is a fine-grained, greenish, meta-basaltic dike, which cuts serpentinized rocks. Some granodiorite intrusions are present also. Locally the dike has been replaced by quartz and pyrite; and oxidizing solutions have stained the mass with iron oxide. It also contains some gold.

Central Mine, owned by C. R. Wiegel, Redding, California, is in Sec. 34, T. 48 N., R. 8 W., 16 miles northwest of Hornbrook over a rough mountain road. According to the owner, a 2-ft. vein occurs along a dike, which is mineralized, assaying $6 per ton in gold; and the granodiorite runs $4 per ton, bringing the total width that can be mined to 6 feet. He states that a block of 2500 tons is developed; and that the block above this, which was mined, had an assay value of $13.50 per ton, of which 50% was recovered by amalgamation. Further treatment is necessary to recover the balance. A log building was erected on the property during the past season; and a compressor is to be installed. This property was not visited during the present survey.

Bibl: State Mineralogist's Report XXI, p. 435; XIV, p. 829.

Log building under construction at Central Mine. Photo by courtesy of C. R. Wiegel.

[23] MacDonald, D. F., *op. cit.*, p. 29.

Cherry Hill Mine (No. 3 on map), 14 claims, 240 acres, unpatented, in Sec. 27, T. 45 N., R. 8 W., is owned by P. D. Thompson of Yreka, and G. A. Reichman of Fort Jones. The property has been worked in a small way for many years. Workings consist of tunnels on both sides of a hill or ridge, which is just to the south of the summit, at a point eight miles southwest of Yreka, on an old road running from Yreka to Fort Jones. The elevation of the camp is 4080 ft.; and a tunnel has been started at this point to give backs of 800 ft. on the veins in the hill. According to P. D. Thompson, it was driven 1800 ft, and has not yet reached the veins. The portal is now caved. About half way up the hill, a 300-ft. tunnel was examined. This is in greenstone for 100 ft., then strikes a vein on end beyond a fault. The vein is only an inch of gouge at first; then an inch of quartz comes in; and farther on it widens to 14 inches. At the 300-ft. point, old stope filling has dropped down and filled the tunnel. The vein strikes east and west, and dips 60° south. The white quartz is banded, with bands $\frac{1}{4}$ inch wide separated by dark lines, each of which probably represents a re-opening of the fissure. Walls are silicified greenstone containing numerous crystals of pyrite. Several branching stringers, an inch to several inches in width, were noted in the footwall.

As one climbs over the top of the hill or ridge to the east, the country rock looks like the greenstone, but seems fresher; and some of it contains inclusions of red jasper or chert probably derived from the series here mapped as Paleozoic and pre-Paleozoic sediments and schists. This indicates that, in addition to the greenstone, younger rocks of similar appearance are present. On the east side of the ridge, near the top, a tunnel was being driven by two men on what is probably the extension of the vein mentioned above. It is about a foot wide here; and the drift is 30 or 40 ft. long. Another vein, 6 inches wide, has been developed by a tunnel 200 ft. lower. The hanging wall is of granodiorite for some distance. On the surface this is seen to be a dike, 100 ft. wide, in the greenstone. Some recent stoping has been done on a third vein with a northeast strike, and dip 21° southeast. A width of 6 to 18 inches of crushed quartz heavily stained with iron and manganese oxides is exposed.

Equipment consists of a mill of four 350-lb. stamps, using amalgamation, and driven by a gasoline engine. Mining is done by hand; and the ore is taken to the mill on horse-drawn sleds.

Commodore Mine (No. 4 on map) is in Sec. 26, 27, 34, 35, T. 46 N., R. 9 W., 30 miles by State highway from Yreka, except the last three miles, which is steep mountain road. The timber, including sugar pine and Douglas fir, is very good on this property, on which elevations vary from 3000 to 3900 feet. Eleven unpatented claims and a mill-site are held by H. J. Barton of Yreka. An option has recently been held by the Swedish American Mining Co., G. W. Matson, president, 1808 101st Ave., Oakland, California. This company has done some work on the property, chiefly cleaning out and retimbering old tunnels. Workings on the old Commodore claim were caved at the time of visit and could not be examined. The remains of a 6-stamp mill, last operated 30 years ago, stand here.

Workings on two other veins were examined. A tunnel on the Insurance vein, 200 ft. long, exposes a vein with a maximum width of 2 ft.

and an average width of 18 inches. The strike is S 70° W.; and the dip 52° to the northwest. A second level on this vein is 250 ft. long, and exposes the vein at a depth of about 300 ft. below the outcrop. It is a fissure vein showing ribbon structure and containing much iron sulphide. H. J. Barton states that it will run $7 per ton in free gold, or $20 per ton total. The Goodenough vein was seen in a crosscut tunnel at a distance of 75 ft. from the portal, where it is 6 ft. wide; but it pinches out entirely in about 20 feet. Caved workings and remnants of old stopes are seen beyond the pinch in the vein. The strike is S. 70°W., and the dip is vertical. A crosscut tunnel, 250 ft. long, at a point 400 ft. below the exposure just mentioned, has cut a stringer zone; but probably this is not the main vein. A prominent feature of the geology is that the veins follow the walls of lamprophyre dikes intruded into the granodiorite.

Bibl: State Mineralogist's Report XXI, p. 437.

Copper Queen is an old prospect, described by MacDonald,[24] three miles east of Carrville, on Copper Creek. Serpentine and andesitic greenstone are cut by a meta-balsaltic dike, in which a zone of secondary chalcocite carrying gold was found.

Cory Prospect. George H. Cory of Callahan is working on a gold prospect in Sec. 29, T. 40 N., R. 7 W.

Dewey Mine (No. 5 on map), in Sec. 6, T. 41 N., R. 6 W., at an elevation of 6800 ft., is held by F. A. Wright, Oakland, California. This was a good producer years ago; but the workings are now closed by caving. An old 10-stamp mill and some cyanide equipment in poor condition remain on the property. The mine was last worked in 1917.

Bibl: State Mineralogist's Reports XIV, p. 831; XXI, p. 438.

Dewey property on Boulder Creek, 1½ miles southwest of Coffee Creek, was described by MacDonald[25] in 1912. A 4-ft. quartz vein, carrying gold with pyrite and chalcopyrite, was developed by 150 ft. of drifting from a crosscut tunnel.

Dorleska Mine (No. 6 on map), in Sec. 20, T. 37 N., R. 9 W., is an extension to the north of the same system of dikes and veins that occurs at the Yellow Rose (which see). The Dorleska was equipped with a small 10-stamp mill; and has an estimated production of $200,000. Workings are now closed by caving. This property has recently been reported under the control of Harry M. Thompson of Redding, who has started to open the Yellow Rose.

Bibl: State Mineralogist's Report XXII, p. 18; U. S. G. S. Bull. 530–D, p. 34.

Eliza Mine (No. 7 on map), in Sec. 4, 5, 8, 9, T. 45 N., R. 8 W., is owned by R. H. DeWitt of Yreka. The mine is reached by means of a fair road, 15 miles long, which turns from the State highway at Hawkinsville, two miles north of Yreka. The last few miles are steep and narrow. The sketch-map (Fig. 1) shows the vein as developed on the fifth level for a length of 800 ft., also the lowest or sixth level, on

[24] *Op. cit.*
[25] *Op. cit.*

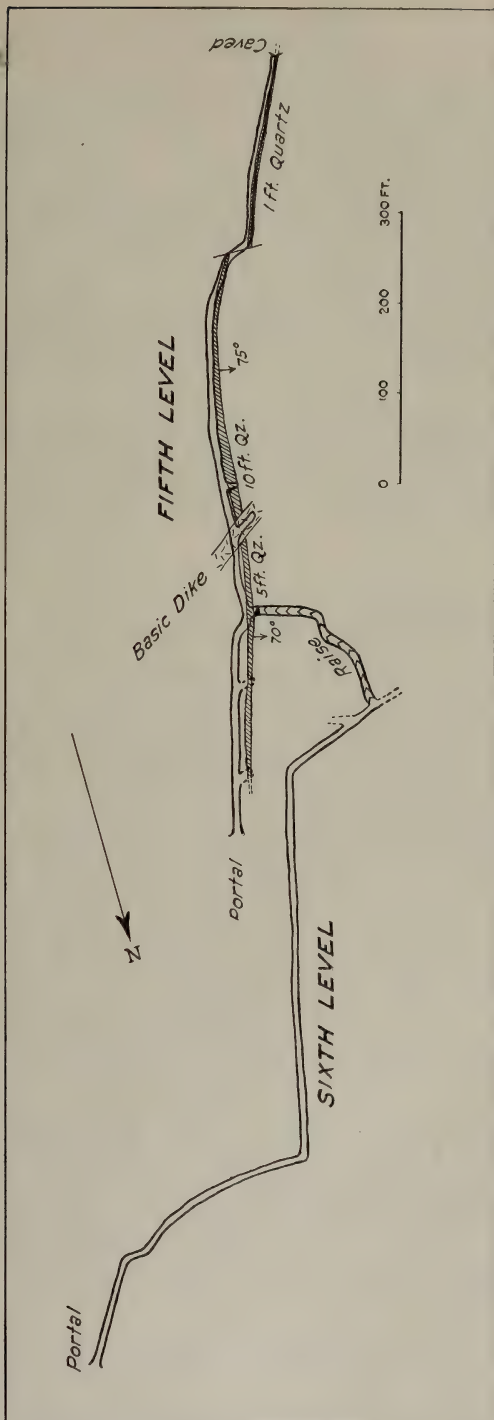


FIG. 1. Eliza Mine, sketch map showing vein on fifth level and outline of sixth level, which is all in country-rock, largely camptonite. Base map after survey plats furnished by R. H. DeWitt. Vertical distance of sixth level below fifth is 224 ft.

which over 1000 ft. of work has been done in the country rock. The difference in elevation between these levels is 224 ft.; and a raise connects them as shown. The vein varies in width from 1 ft. to 10 ft.; but only wall is exposed in many places as indicated on the sketch. It is a typical fissure vein with ribbon quartz containing arsenopyrite, sphalerite and galena in small amounts.

O. H. Lawson, who was doing assessment work at time of visit, estimates the average value per ton at $7.60 in gold. The exposures are large enough to warrant systematic sampling and the preparation of an assay map, which is not available at present. Lawson states that the ore is all in place from the fifth level to the fourth, on which 500 ft. of drifting has been done, a vertical distance of 137 feet. All ore above the fourth has been stoped, except a length on the strike of 180 ft. where the ore was base. This ore was treated by amalgamation in an old 10-stamp mill, operated by water power, that stands on the property. Past production has been reported as about $150,000.

Short crosscuts from the raise should locate the vein, and point the way for additional development work on the sixth level.

Bibl: State Mineralogist's Reports XIV, p. 831; XIX, p. 138; XXI, p. 439.

Empire Mines, see under Copper.

Fidelity Metals Corporation, see Schroeder.

Gilfeather Prospect (No. 8 on map) is on the ridge east of Collins Creek, at a point about two miles south of the road along Klamath River. Collins Creek flows into the Klamath 2½ miles west of Oak Bar. Owners are J. B. Nowdesha of Hamburg, California, and J. J. White of Sacramento. The workings are near an intrusive contact between the granodiorite, and the metamorphic series included on the map under Paleozoic and pre-Paleozoic, which is here represented by a quartz schist. A vein, 3 to 18 inches wide, of heavily iron-stained white quartz, showing a few spots ¼ inch in diameter of pyrite and galena, is exposed in a dike of the granodiorite for a distance of 10 feet. From the dike it passes into the schist. This vein is developed by means of several open cuts, 10 to 15 ft. long. Another vein of smaller appearance, exposed in the partly-caved portal of a tunnel, has walls of granodiorite. Another tunnel, 50 ft. long, penetrates the weathered zone in the granodiorite, and reaches fairly fresh rock. The weathering extends to a considerable depth here, the rock on the surface being reduced to sand.

Gold and Nickel (No. 9 on map) is in Sec. 35, T. 42 N., R. 7 W., and Sec. 2, T. 41 N., R. 7 W., 12 miles southwest of Gazelle by a fair road. This group includes 10 claims; and several other groups of similar size are held in the vicinity by the same persons. A road to the workings turns to the left just beyond the summit on the road from Gazelle to Callahan. Owners are James F. Furlong, P. M. Furlong, and Fred Gould, all of Gazelle, and Erwin P. Warner, City Attorney, Los Angeles.

A 45-ft. shaft, 30 ft. of which was open to inspection, shows quartz heavily stained with iron oxides. The material resembles gossan, and contains occasional spots of pale yellow and black sulphides. They are probably mostly iron compounds; but a pale-green staining indicates that

nickel may be present. About 1000 ft. south of this shaft, the 'North Tunnel' has been driven for 300 ft. in siliceous vein matter containing pyrite. Chunks of this sulphide have been sorted out and piled in the tunnel to the extent of 200 or 300 tons. If one walks south from this tunnel on the surface, siliceous outcrops are seen for several thousand feet with spots of gossan at intervals. The formation appears to be quartzite or chert full of veinlets of secondary quartz. Dikes or basic rock altering to serpentine are associated with the sulphide deposits. The 'South Tunnel' has been driven 500 ft. in siliceous material; and slates show in the face with a strike of N. 25° E., and dip 65° west. Three hundred feet to the west is the 'Southwest Tunnel', which starts in gossan, and enters siliceous material near the face. Plans were under way at the time of visit to finance the exploration of the property with diamond drills.

Gold Dollar is an old prospect on a 2½-ft. quartz vein, three-quarters of a mile north of Carrville. A small mass of granodiorite porphyry cuts the serpentine; and an aplite dike, 25 ft. thick, cuts the granodiorite. The vein, containing free gold, pyrite, and iron oxide, cuts all three of the formations mentioned.[26]

Golden Age Prospect (No. 10 on map), in Sec. 4, T. 45 N., R. 9 W., consists of three unpatented claims on the steep slopes of McKinney Creek, 6½ miles by a poor road south of the Klamath River. Owners are E. W. Cooper and F. M. Kirkland, address Walker, California. Several cuts and caved tunnels expose a vein from 18 inches to 4 ft. wide on the steep slope of the mountain for a length on the strike of 200 feet. The strike is southwest and the dip 70° to 80° northwest. Below, on the opposite side of the creek, a cut with a 10-ft. face exposes what may be the same vein, strike S. 80° E., dip 60° north. The width here is 6 ft.; and the quartz is stained with oxide of iron, and contains patches of pyrite, galena and sphalerite. Walls appear to be granodiorite. The workings are too shallow to get into wall-rock fresh enough to determine with certainty. Some of the wall-rock is soft, decomposed material stained yellowish brown by oxide of iron, one of the many substances called 'porphyry' by prospectors. All exposures of rock noted in the vicinity were dioritic. Owners estimate by panning that the quartz will run $7 to $8 per ton in free gold, and state that the vein has been opened at intervals for a total length of 2000 feet.

Nearby the same persons hold five claims and a millsite, including the old Golden Eagle claim (see State Mineralogist's Report XXI, p. 441). This is called the K. C. group. Owners state that a vein with an average width of 2 ft. and a maximum of 5 ft. is opened at intervals, by means of seven cuts for a length of 1200 ft. on the slope of the mountain. An assay certificate, giving returns on three samples stated to have come from this vein, showed returns of $33 to $155 per ton. The K. C. group was not visited during the present survey.

Golden Eagle Mine (No. 11 on map), in Sec. 11, T. 44 N., R. 9 W., 10 miles north of Fort Jones, is owned by George A. Milne of Fort Jones, who owns several other patented mining claims and other patented ground adjoining. The mine has been worked at various times for

[26] MacDonald, D. F., *op. cit.*, footnote (21).

Hoist at Golden Eagle Mine.

Mill at Golden Eagle Mine.

many years, total production being estimated at $1,000,000 by the owner. In 1927, the Sterling Gold Mining Company, backed by Oakland people, did some work here; but little production resulted. The lowest level, 225 ft. below the surface, is shown on the accompanying map (Fig. 2), which also shows the veins developed, and the relations to the country rock. The dike in which the shaft is located is thought by Milne to be later than the period of mineralization that produced the ore. However, relations shown on the map, with one vein in the dike for a short distance, and another having the dike as the hanging wall, indicate that a period of quartz vein formation followed the intrusion of the dike. Milne states that the best ore came from a shoot raking to the south, where the note 'caved stope' is made on the map; and he thinks that the best way of proceeding with development work to find new ore is to sink the shaft and open up this shoot below.

The old mill from the New York mine has been moved to the Golden Eagle and set up with another mill. The combined plant now consists of the following: rock crusher, six 1000-lb. stamps, ten 850-lb. stamps, amalgamating plates, and an Overstrom table. This machinery is driven by electric motors of 40, 50 and 5 horsepower. At the mine are a 50-hp. electric hoist, Giant compressor, 2 cylinders, single stage, driven by a 50-hp. motor, three jackhammers, ore cars and tools. A 2-inch, 4-stage centrifugal pump is used to keep the shaft unwatered; and three air-driven pumps are on hand. A small assay office, fully equipped, also stands on the property.

Bibl: State Mineralogist's Reports VIII, p. 625; XIV, p. 832; XXI, p. 440.

Golden Eagle Claim in Sec. 6, T. 45 N., R. 9 W., see Golden Age.

Golden Jubilee Mine (No. 12 on map), in Sec. 4, T. 37 N., R. 8 W., five miles northwest of Carrville, is owned by D. V. Saeltzer of Redding. A company called Golden Jubilee, Inc., Pine and Main Streets, Niagara Falls, New York, is operating the mine. Wm. Kremers is president, and C. H. Kremers is secretary. A. H. Williams of Coffee, Trinity Co., California, is vice-president and superintendent; and L. G. Williams, also of Coffee, is a director.

A fissure vein, discovered in 1892, is developed by seven adits, ranging in elevation from 3050 to 3700 feet. The strike is N. 20° E., dip 75° to 85° east. Present operators have advanced the No. 5 level to a total length of 2200 ft., of which 900 ft. is new work. At the time of visit a raise was being driven from near the face to connect with the upper levels and furnish a means of transporting ore to the mill. The total distance from No. 5 to No. 3 level is 260 ft., and this raise has since been finished. The new work on the lower level and in the raise is on a mineralized fracture thought by operators to be the main vein; and some bunches of ore have been found on it. The dip indicated by the surveys of the new work is steeper than that of developed portions of the vein on the upper levels. Above No. 3, the dip is 75° to 76°. The indicated dip to connect the new work with the old is 80° to 85°; and the dip of the fracture on the No. 5 level checks the latter. The new raise is directly under a raise above No. 3 level, in which a block of ore is developed on three sides between No. 1 and A levels. This block is

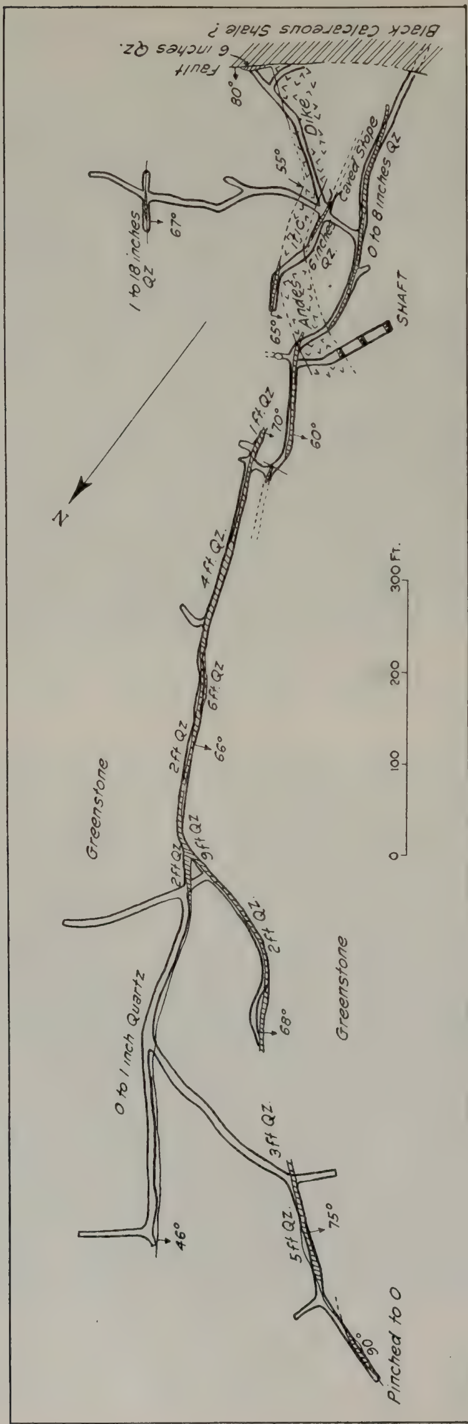


FIG. 2. Golden Eagle Mine, plan showing the geology of the bottom or 225-ft. level. Where not otherwise indicated, the formation is greenstone.

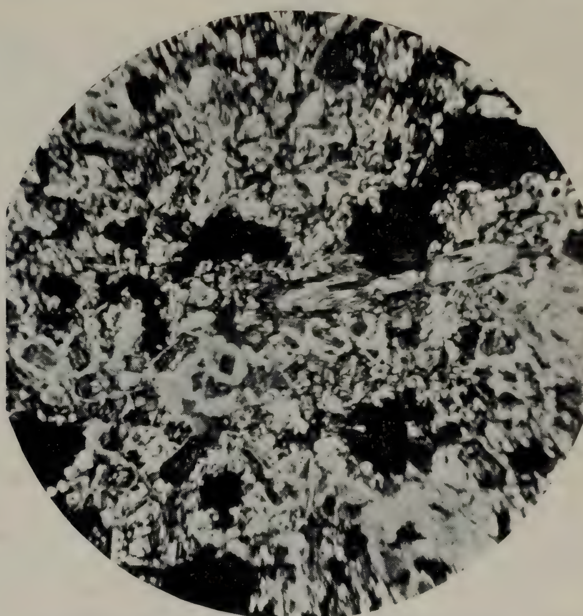
about 3 ft. in average width, with a maximum of 8 ft., and a value of \$16 to \$17 per ton. At a point 160 ft. farther ahead in the A drift, the assay map shows samples of from \$50 to \$150 on a vein two ft. wide. Several of the old levels were caved at the portals, and were being reopened at the time of visit. In the A level the walls are a decomposed granodiorite, which runs like sand; and spiling was necessary to reopen it. Following are the approximate elevations of the levels:

B	3700 ft.
A	3600 ft.
No. 1	3500 ft.
No. 2	3400 ft.
No. 3	3350 ft.
No. 4	3300 ft.
No. 5	3050 ft.

Power for a 10-stamp mill, small cyanide plant, 9-in. by 8-in. compressor, old Huntington mill, and concentrating tables was furnished by water taken from Boulder Creek through a mile of ditch and 1000 ft. of 6-inch and 10-inch pipe. Present operators experienced trouble from leakage, and replaced the ditch with pipe as follows, 250 ft. of 10-inch, 100 ft. of 11-inch, 200 ft. of 17-inch, balance 8-inch to make a total of 6000 feet. Head is 235 feet.

The ore is a white quartz in stringers in the granodiorite, carrying free gold, sylvanite, pyrite and galena. Between the stringers the granodiorite is replaced and mineralized. Associated with the veins are small lamprophyre dikes, usually only a few inches wide; but occasionally they widen in irregular lenses. Apparently a small dike was intruded into the granodiorite, and was then broken into sections by small cross-faults. Another break, into which the vein later made its way, then followed the old direction of weakness, which the small dike had made in the granodiorite. The new break was able to follow the old only approximately, because the old break had been offset by the cross-faults in the meantime. Evidence of this is seen in sections of the continuous vein which have the small dike as one wall. At a mineralized cross-fracture the dike ends; but the vein continues through the granodiorite. Farther on, a section is found with the small dike again forming one wall of the vein. This dike rock is dark greenish-gray in color, and is of very fine grain. In the narrow parts an occasional crystal $\frac{1}{32}$ inch long may be seen; but most of them are much smaller. In the wider lenses, dark green, almost black crystals of hornblende of a maximum length of $\frac{1}{4}$ inch appear in a groundmass of gray color and fine grain. With a lens a few of the larger white feldspar crystals are seen. Under the microscope the rock is found to be composed of phenocrysts of andesine-labradorite and hornblende in a groundmass of similar composition. Zonal extinction in the feldspars, showing a variation in composition from the centers to the edges is common. The abundant green hornblende crystals have started to alter to chlorite; and some of them are strained and bent. Feldspars are altering to sericite. Accessory magnetite and apatite are present. The rock is a spessartite, a lamprophyre of about the composition of a basic diorite or andesite.

Other dikes, cut in the main crosscut tunnel on No. 5 level, strike at nearly right angles to the vein. Where exposed, these dikes have no vein quartz with them, and are coarser in grain than the dikes found with the vein. The rock is holocrystalline with grain size varying from 1/32 to 1/8 inch. An occasional hornblende crystal reaches a length of ¼ inch. The light and dark minerals appear about equal in quantity; and the long thin crystals of green hornblende are very prominent. Under the microscope the rock is seen to be porphyritic, with a few crystals of feldspar and hornblende larger than the general run of those in the holocrystalline groundmass, in which flakes of biotite are abundant. Zonal growth is very prominent in the feldspar, which has a small angle of extinction on the edges, and a large angle at the center. The variation in composition from the edges to the center is from oligoclase to basic labradorite. Plagioclase feldspar is by far the most abun-



Photomicrograph of thin section. Nicols crossed. Enlarged 25 diameters. Kersantite from Golden Jubilee mine. One end of a hornblende needle is near the center of the field; and several small plagioclase crystals show zonal extinction, white on edges and dark in center

dant mineral in the rock, with crystal outlines well developed. Other minerals in order of their relative abundance are hornblende, biotite, orthoclase, quartz in a few interstitial grains, magnetite and apatite. The rock is a kersantite, a lamprophyre differing but slightly in composition from that associated with the vein. The granodiorite from this mine is described in a preceding part of this report.

Bibl: State Mineralogist's Report XXII, p. 21; U. S. Geological Survey, Bull. 530–D, p. 27.

Gold Road Group (No. 13 on map) comprises the SE. ¼ of the SE. ¼ of Sec. 23, T. 45 N., R. 8 W., and adjoining ground to make a

total of seven claims containing 110 acres, adjoining the property of the Mount Vernon mine. The group is held by Kenneth K. Ash of Yreka. Some old workings, made about 1900, have recently been opened and sampled. According to Ash, a 50-ft. drift on a vein of ribbon quartz of an average width of 4 ft. was sampled each five feet; and the average assay returns were $8 per ton in gold, with a maximum of $19. Walls are greenstone. About 100 ft. more of drift could be seen with water dammed up in it, also a 35-ft. winze full of water. No outcrop of this vein is visible, the surface being covered deeply with soil.

Gumboot Mine (No. 14 on map), in the NE. ¼ Sec. 16, T. 45 N., R. 9 W., consists of five unpatented claims held by Jack McInnes and Philip McCool, both of Scott Bar. It is seven miles by road east of Scott Bar; but the last 1½ miles are too steep for an automobile and are used as a sled-road only. Main workings (see Fig. 3) at present consist of a crosscut adit, 120 ft. long, passing through a series of impure limestones and slates, striking S. 22° E. and dipping 60° southwest. At the 120-ft. point is a drift on the vein 100 ft. in length. A raise

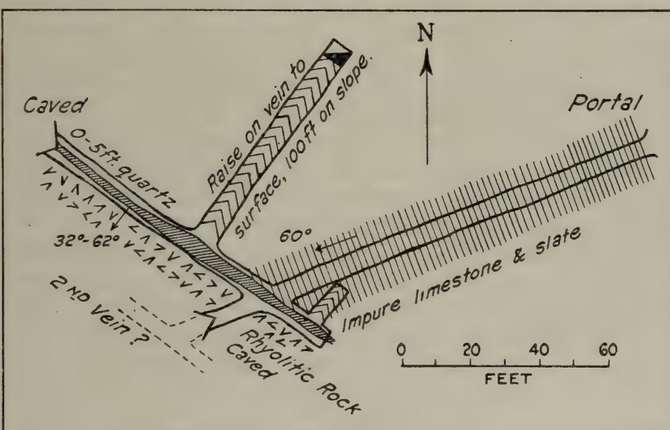


FIG. 3. Gumboot Mine, sketch map of main working level.

from this drift connects with the surface, length 100 ft. measured on the dip of the vein, which strikes N. 55° W., and dips from 32° to 62° to the southwest. It varies in width from nothing to 5½ feet, with an average of 3 feet. A shipment of 18 tons from half way up this raise, said to have been unsorted, is stated by the owners to have brought gross returns of $75.73 per ton, 6 oz. being in silver, the balance gold. The ore is white quartz showing oxides and galena. The hanging wall is rhyolitic; and the footwall is calcareous slate.

Other veins show in shallow prospect cuts on the surface. One of these strikes S. 40° E. and dips 45° southwest. At an elevation 70 ft. below, a 300-ft. tunnel is being driven through calcareous slate to cut this vein. At an elevation 200 ft. below the main working tunnel, is a 200-ft. tunnel, which was started about 30 years ago to tap the veins. It passes through a metamorphosed sedimentary series, quartzite, limestone and slate.

Hathaway Prospect (No. 15 on map), the NE. ¼ Sec. 11, T. 40 N., R. 9 W., is assessed to Albert S. Hathaway, Sugar Creek Mining Co., 410 Holm Boulevard, Los Angeles. The Sugar Creek Mining and Milling Co., C. Ray LaMar, president, 365 S. Cloverdale, Los Angeles, has done a little recent work on the property. At the time of visit, M. P. Mullen, Gazelle, California, was the only one there. A 340-ft. tunnel passes through impure limestone; and a drift has been driven on a vertical seam for a distance of 50 feet. The seam strikes N. 20° E., and has a width of one foot. The filling is a highly oxidized gouge, showing green copper staining and specks of sulphide. Mullen stated that this assays $10 to $12 per ton, and that, years ago, it produced $60,000 from a stope 95 ft. high, 85 ft. long and 30 inches wide. A raise from this lower level taps the stope; and 94 ft. above a second tunnel connects with the stope. The seam is in a basic dike, of which only one wall is exposed. The part of the dike that can be seen in the workings measures 32 ft. in width; and it has the same strike and dip as the seam mentioned above. The series of limestones, slates and cherts strikes S. 74° E., and dips 61° S.

The Stevens tunnel is 400 ft. long; and it exposes a dike of similar basic rock, showing calcite seams, iron-oxide stain, and green copper stain. Mullen stated that an 82-ft. width of this assayed $4 per ton in gold. On railroad land in the S.W. ¼ of Sec. 11, on which the company was said to have an option, is a vein with a maximum width of 5 ft., on which a tunnel 420 ft. long has been driven. The strike is N. 26° E., and the dip 57° to 80° northwest. The vein is similar in appearance to that first described; but the dark colored dike is lacking. A high content of lime also tends to lighten the color. The vein matter is highly stained with brown oxides of iron, and in places shows a high sulphide content. An 85-ft. raise was said by Mullen to have given an average assay return of $31 per ton for a 30-inch width. The footwall is a gray chert; and the hanging wall is an impure limestone.

A 45-ton ball mill and concentrating tables were on the property, also a two-drill compressor, 10 by 12 inches, with two receivers. None of this machinery had been installed.

Hazel Mine, formerly Jillson, (No. 16 on map) in Sec. 31, T. 47 N., R. 6 W., and Sec. 25, T. 47 N., R. 7 W., four miles southwest of Hornbrook, is the property of the Hazel Gold Mining Co., C. F. Kimball, secretary, 1103 First National Bank Building, San Francisco. Quartz veins, 3 ft. wide, carrying gold are found near the contact of the metamorphic series, called in this report Paleozoic and pre-Paleozoic sediments and schists, and the greenstone. Greenstone is the more prominent formation on the surface; but the dumps indicate that much of the work may have been in other formations. The mine has been idle for some time; and the workings were not examined. Reports of the State Mineralogist (see bibliography) state that the walls are slate. With the exception of one or two old buildings, and a 14-in. by 9-in. by 10-in. compressor, two-stage, connected by belt-drive to an 85-hp. motor equipped with starter, little remains on the property. The mill has burned. An interesting exposure of the basal conglomerate of the Chico formation is seen a quarter of a mile east of the mine. It is composed largely of pebbles and cobbles of various igneous rocks, andesites,

diorites, greenstone, etc., also some chert. To the west of the mine workings is an outcrop of white and gray chert.

Bibl: State Mineralogist's Reports XIV, p. 833, XXI, p. 442.

Headlight Mine, in the NW. ¼ Sec. 21, T. 37 N., R. 7 W., one and a half miles southeast of Carrville, was the most important mine of that district at the time that MacDonald [27] made his report in 1912. He includes three sketches to illustrate the occurrence of the ore replacing a basaltic dike in granodiorite porphyry. The rocks present in the sequence of their age are andesitic greenstones, slates, granodiorite porphyry, greenish basaltic dikes, and lamprophyre dikes of about the composition of vogesite. The ore contained free gold, and was much iron stained. Occasional kernels of unoxidized pyrite and a little chalcopyrite were found. To expose the deposit, overburden was removed with a hydraulic giant. Ore averaging $6 per ton was treated in a 40-stamp mill and a cyanide plant of 250 tons capacity. Nothing has been done here recently.

Bibl: State Mineralogist's Reports XIV, pp. 892, 893; XXII, pp. 22, 23.

Johnson and Lewis group (No. 17 on map) is a group on which some work has recently been done by the Superior Consolidated Mines Co., 920 Lloyd Building, Seattle, Washington, with S. W. Steffner of Fort Jones as superintendent. The Johnson includes two patented claims assessed to John J. Johnson and others of Etna; and the Lewis comprises four unpatented claims adjoining. The location is Sec. 18, 19, T. 43 N., R. 9 W., near the Morrison and Carlock mine. A quartz vein, 2½ ft. wide, is exposed on the surface for 1000 ft., exposures not being continuous, but at intervals only. Free gold can be seen in some of this quartz. A drift-tunnel on the vein, 110 ft. long, gives a depth of 110 ft. below the surface at the face, and, if continued to 1000 ft., will give 250 ft. of backs. An 80-ft. crosscut tunnel at about the same level has not yet reached the vein. Relations between the various kinds of country rock are complex here, slate, limestone, andesite and rhyolitic breccia being noted. The company named above has also recently controlled the Morrison and Carlock and the New York mines (which see).

Jubilee, see Golden Jubilee.

K. C., see Golden Age.

Lily of the Valley is a prospect near Coffee Creek at an elevation of 4600 ft., on a 10-inch vein carrying gold and pyrite, with possibly some tellurides. The country rock is granodiorite cut by dikes.[28]

Lost Horse Prospect, formerly known as the Peterson or Ruggles (No. 18 on map), in Sec. 4, T. 37 N., R. 7 W., is owned by George W. Elliott of Carrville. From Carrville, it is two miles by road to the Strode mine, then three miles by trail up Trinity River and Scorpion Creek to the Lost Horse. The elevation is 3500 ft.; and good supplies of both water and timber are found on the property. Workings are

[27] MacDonald, D. F., *op cit.,* footnote (21).
[28] MacDonald, D. F., *op. cit.*

on both sides of a ridge between Scorpion Creek and a small tributary, the distance through which is 1500 or 2000 feet. On the northwest side of the ridge a vein was observed in the portal of a tunnel with a strike of N. 15° W., and dip 70° W., and a width of 2 ft. of fractured, iron-stained quartz. A 50-ft. winze just inside the portal of this tunnel was stated by Elliott to have yielded two samples of $100 and $88 recently. An arrastra is said to have been profitably operated here years ago. John H. Dequer of Los Angeles, who holds an option on the property, is preparing to install a one-drill compressor driven by a gasoline engine, and to prospect the vein. On the opposite side of the ridge some work has recently been done in a tunnel several hundred feet long. The face is in a quartz-stringer zone in gabbro. Andesitic or rhyolitic dikes, of fine grain, much decomposed, and stained with oxides of iron, were observed in this tunnel. An old mill of five 450-lb. stamps stands on this side of the ridge.

Lucky Strike Group, formerly known as the Asgood, 26 unpatented claims, in Sec. 16, 21, T. 45 N., R. 7 W., two miles west of Yreka, is owned by J. E. Hubbart. Old workings from a 150-ft. shaft with connecting tunnel, on narrow quartz veins, are described in the reference given below. About 1926, an old tunnel was extended to a length of 400 ft.; and an additional 200 ft. of lateral work was done from it. This developed several small seams of quartz, an inch wide. In some of the surface cuts, which are very numerous in the vicinity, the quartz reaches widths of 1½ ft. and 2 ft. Pyrite is abundant both in the quartz and the greenstone country rock; and sphalerite, galena, and free gold were noted in the quartz. J. C. Hubbart of Yreka, who is working on the property, states that gold is found in the country rock, particularly near the quartz seams. He is planning to use the five-stamp mill on the property as a pilot plant to determine whether the country rock can be mined with the quartz to give a large tonnage of low grade ore. In the gulch above the workings, dikes of a fine-grained, acid rock cut the greenstone. Small specks of sulphide, probably pyrrhotite, are seen in this with a lens. Some of the greenstone here is a little coarser in grain than the typical variety found throughout the northwestern part of the Shasta quadrangle. The vesicular variety and the agglomerate or breccia occur here also. The Risdon mill of five 1050-lb. stamps is equipped with a 35-hp. electric motor; and a compressor with a 50-hp. motor. An assay office was being built at the time the property was visited.

Bibl: State Mineralogist's Report XXI, p. 454.

McKeen Mine, see Oro Grande Mining Co.

Morrison and Carlock Mine (No. 19 on map), in Sec. 13, T. 43 N., R. 10 W., four miles northwest of Greenview, is assessed to M. C. Beem and Geo. A. Milne of Fort Jones. Some recent work has been done by the Superior Consolidated Mines Co., 920 Lloyd Building, Seattle, Washington, with S. W. Steffner of Fort Jones in charge. This company has also held options on the Johnson and Lewis and on the New York. During most of 1930, these properties have been idle; and when the Morrison and Carlock was visited all levels below the fifth were under water. The mine is developed by an incline shaft, at an average

angle of 60° with the horizontal, in the footwall of the vein. This reaches the fifth level at a vertical depth of 191 ft., where the vein has been exposed for a length of more than 1000 ft., and has been stoped out. From this level a second incline, 351 ft. long, reaches the ninth level at an elevation 168.5 ft. below the fifth. The vein has been only partly stoped below the fifth level; and the owners state that some good ore is exposed on the lower levels. Where seen by the writer on the fifth level, the vein averages 16 to 18 inches in width; and the dip is 32° to the east. The strike varies in north and northwesterly directions. Walls are of greenstone. At both ends of the workings on the fourth and fifth levels, faulting is evident; and workings beyond the faults have picked up some quartz. Maps of these ends are not available; and a detailed study of this faulting will be impossible until an accurate survey of the workings is made and plotted. Equipment includes an old 10-stamp mill, hoist, compressor with gasoline engine, pumps, and connection to the electric power lines.

Bibl: State Mineralogist's Reports XIII, p. 413; XIV, p. 837; XXI, p. 450.

Mount Vernon Mine (No. 20 on map), 70 acres of patented and 40 acres of unpatented ground, in Sec. 26, T. 45 N., R. 8 W., is assessed to Stella V. Dobyns of Dunsmuir. The mine is eight miles west of Yreka by a good road at an elevation of 4434 feet. It has been worked irregularly for more than 50 years. A syndicate with Kenneth K. Ash of Yreka as manager has recently done 915 ft. of new development work on the fifth or mill level, which is 1000 ft. below the outcrop on the dip of the vein. This level (Fig. 4) now consists of a 650-ft. crosscut to the vein, 900 ft. of drifting on a vein with strike S. 10° E., dip 41° E. at face, 130 ft. of drifting on a footwall branch vein, strike S. 16° W., dip the same as the other, and a 40-ft. crosscut between these. The crosscut exposes a stringer zone between the two veins. Ash estimates that a width of 8 ft. of this ran $8 per ton on the mill test. The veins are on fault fractures, and show a width of from 0 to 2 ft. of ribbon quartz, which contains a little pyrite, galena and sphalerite. The quartz is fractured and broken, indicating movement on the old plane of weakness since the veins have been formed. Ash thinks that the Mount Vernon vein, worked on the old levels, has not yet been found on this level. An old raise starts from the main drift on the fifth level and runs 550 ft. to a point above the third level, from which point there is a crosscut 140 ft, long to the Mount Vernon vein. Caving conditions make it impossible to survey these workings. From the fifth level the operators have recently sunk a 95-ft. winze, which was full of water to a point 20 ft. below the level at the time of visit. Ash states that a sample from the 30-ft. level in the winze, width 12 inches, assayed $97 per ton. According to Ash, in 1928-29, a mill run of 775 tons was made on material that was diluted 5 to 1 with country rock, which, however, may carry a little gold near the vein. Recovery was $4.65 per ton in free gold; and concentrates were saved, which are estimated at 6 tons running $97 per ton. No concentrates were obtained from the first 265 tons, which were milled before the concentrator was installed. A No. 6 Wilfley table has been added to the 5-stamp mill; and other new equipment includes a two-drill Sullivan single-stage compressor, with

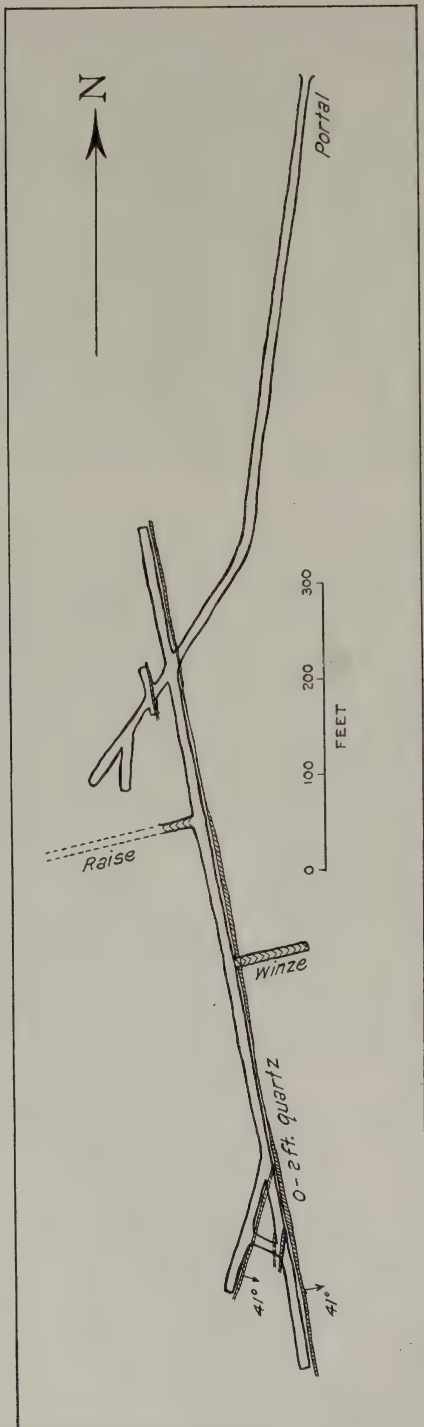


FIG. 4. Mount Vernon Mine, sketch map of fifth or mill-level. Country-rock is amygdaloidal greenstone and greenstone agglomerate.

40-hp. motor. On the winze are a 5-hp. geared hoist, 3-hp. motor and blower, and a self-dumping skip of 1500 lbs. capacity. The power line of the California-Oregon Power Co., running to Fort Jones, crosses the property.

South of the main workings of the Mount Vernon, a specimen was taken from an open cut on a 20 to 30-ft. dike. In the hand specimen it is a light-colored gray rock with a suggestion of a cream color, but darker. A few phenocrysts of quartz and somewhat more numerous needles of a highly altered mineral, probably hornblende, are seen in a very fine-grained ground mass. Maximum diameter of the quartz phenocrysts is $\frac{1}{16}$ inch and maximum length of the dark needles is less than $\frac{1}{8}$ inch. Under the microscope, large phenocrysts of feldspar are fairly abundant; but they are almost entirely altered to sericite. An occasional crystal of quartz or bleached biotite is seen. The rock is highly silicified, the groundmass consisting now of finely crystalline quartz of secondary origin and microscopic flakes of micaceous material. Much of the iron has been leached out of the rock. The needles, thought to be hornblende, are very indistinct under the microscope, because they have been entirely altered to secondary minerals. A few of the feldspar crystals show unaltered parts that can be recognized as albite. The original nature of the rock is uncertain; probably it was rhyolitic, perhaps dacitic. The type of alteration is interesting, as it indicates that mineralizing solutions have been acting on this dike. This dike is intrusive into the andesitic greenstone.

Bibl: State Mineralogist's Report XXI, p. 452.

Mullen Prospect (No. 21 on map), in Sec. 2, T. 40 N., R. 9 W., is held by M. P. Mullen of Gazelle and Otto Schmale of Chico. The group consists of three claims adjoining the Hathaway holdings to the north. A 420-ft. tunnel exposes a basic dike in the serpentine, similar to that at the Hathaway. A mineralized seam, averaging 18 inches wide for a length of 50 ft., shows prominent pyrrhotite. Mullen states that this assays $10 to $12 per ton in gold.

New York Mine (No. 22 on map), in Sec. 2, T. 44 N., R. 9 W., Mineral Survey 4134, is owned by George A. Milne of Fort Jones; and has recently been optioned by the Superior Consolidated Mines Co., 920 Lloyd Building, Seattle, Washington. It was first worked in 1856, and was later reported to have been developed to a depth of 800 ft. on an incline of 45°. Numerous veins and seams were worked, with the pay ore averaging about two feet in width. Nothing has been done here recently. The mill has been moved to the Golden Eagle, a short distance to the south.

Bibl: State Mineralogist's Report XXI, p. 452.

Nigger Boy Mine, in Sec. 2, T. 46 N., R. 7 W., five miles southwest of Hornbrook, was located in 1898. A vein two feet wide occurs in slate and diorite. It was equipped with a two-stamp mill. Some recent work has been done at this prospect; but the writer learned of it too late in the season for a visit.

Bibl: State Mineralogist's Reports XIV, p. 837; XXI, p. 452.

Oro Grande Mining Co. The McKeen mine (No. 23 on map) of this company is in Sec. 36, T. 40 N., R. 9 W., near Callahan or 31 miles from the railroad at Gazelle over a good road. Hugh McKinnie, Callahan, California, is president and R. D. McKinnie is secretary. The property comprises 480 acres of patented land at an elevation of 4000 feet. Plenty of water from Boulder Creek, and good pine, fir and cedar timber are available on the property. It was discovered in 1881; and was last worked in 1929. Four veins are known; but only one has been developed. This is a fissure vein of white quartz with pyrite. The pyrite forms about 10% of the vein filling; and the gold is in pyrite. The vein, of an average width of 2 ft. and a maximum of 5 ft., strikes S. 35° W., and dips 85° to the southwest. On the lowest or No. 1 tunnel level, 2825 ft. of drifting have been done; and on the No. 2 level, 220 ft. above, 2300 ft. of drifting. A raise connects the two levels at a point 1500 ft. from the

McKeen Mine of Oro Grande Mining Co.

portal of No. 1 tunnel. Levels above No. 2 are stoped out and caved. Between No. 1 and 2 levels, owners claim ore reserves of 30,000 tons of ore of a value of $8 per ton. They state that three pay shoots have a length of 250 ft. each, and that the No. 1 tunnel has been in a shoot for the last 75 ft. The vein has a gouge parting on both walls and breaks clean of country rock without difficulty in the shrinkage stopes.

Equipment includes a compressor, capacity 500 cu. ft. of free air per minute, machine drills for both stoping and drifting, cars and track. In the mill are a Blake crusher, Hardinge ball mill, Dorr classifier, two 10-ft. amalgamating plates, K & K flotation machine. The capacity is 35 tons through 60 mesh in 24 hours, with an extraction of 90%. A laboratory test with cyanide is stated by Hugh McKinnie to have an extraction of 94 to 96%. He says that a production of $250,000 is recorded and that probably an equal amount additional has been produced but not recorded. The only recent milling was a test run of

10 days in 1929. Water power from Boulder Creek is used to drive the machinery. A mile of ditch and 1000 feet of 14-inch pipe supply 500 miner's inches with a 260-ft. head.

Numerous cuts and small tunnels were observed on quartz veins on the slope of the hill to the northwest of the mine. As one climbs this hill the float changes from granodiorite, which forms the walls of the McKeen vein, to serpentine, showing that the deposit is very close to the contact. Pieces of float of white, aplitic-appearing material, with only scattered cyrstals of biotite, are common in places on this slope also.

Osgood, see Lucky Strike.

Poeth Mine is on the west side of Boulder Creek near the Golden Jubilee. The geology of the two is similar, granodiorite cut by lamprophyre dikes. Some high-grade ore has been produced from a quartz vein, three feet in average width, by sorting.[29] This property has not been worked recently.

Quartz Hill Mine (No. 24 on map) is a property of about 75 acres of patented ground in Sec. 16, T. 45 N., R. 10 W., at the Junction of Mill Creek and Scott River, near the town of Scott Bar. By road it is about 45 miles from either Yreka, the county seat of Siskiyou county, or Hornbrook on the main line of the Southern Pacific railroad from San Francisco to Portland. Thirty miles of this road are graded highway following the Klamath River; and the balance is fairly good. Patents are covered by Mineral Surveys, Lot 37, Marfield & Co. Placer Mine, and California Placer Mine, M. S. 3493. The owner is Harry G. Noonan, 2801 Jackson St., San Francisco. In 1860, or earlier, the mine was started as a hydraulic mine working on material eroded from the large system of quartz veins now exposed. A small mill of 10 stamps of 750 lbs. each was used in some of this early work, with amalgamation for the recovery of the gold. Present operators have worked the deposit for 25 years. Three or four men blast the hard quartz and schist and then hydraulic this broken material. Giants, discharging a large volume of water at a high pressure, wash the broken rock through a regular sluice with riffles in the bottom to catch the gold. The face of the pit is examined after each blast; and if any high grade is found it is sorted out and crushed in a small ball mill, run by a 5-hp. air motor, and equipped with amalgamating plates. The photographs and the sketch-map (Fig. 5) show the present appearance of the mine. Positions from which the photographs were taken are indicated on the sketch-map. The largest lens of quartz, that is the one between the two possible fault lines, is the same as the high outcrop just to the left of top-center in photograph No. 1. The sketch-map shows only the largest of the veins that are actually exposed. Innumerable smaller lenses down to a length of only a few inches are scattered throughout the schist; and gold is at times seen in these. By referring to the photograph, it is seen that a large area (shown blank in the center of the sketch-map) is covered with tailings. Additional veins may exist under these. The mine superintendent, George Noonan, states that at high water in the river, when the bottom is swept clean of debris, he has seen a large vein exposed under the bridge.

[29] MacDonald, D. F., *op. cit.*, footnote (21).

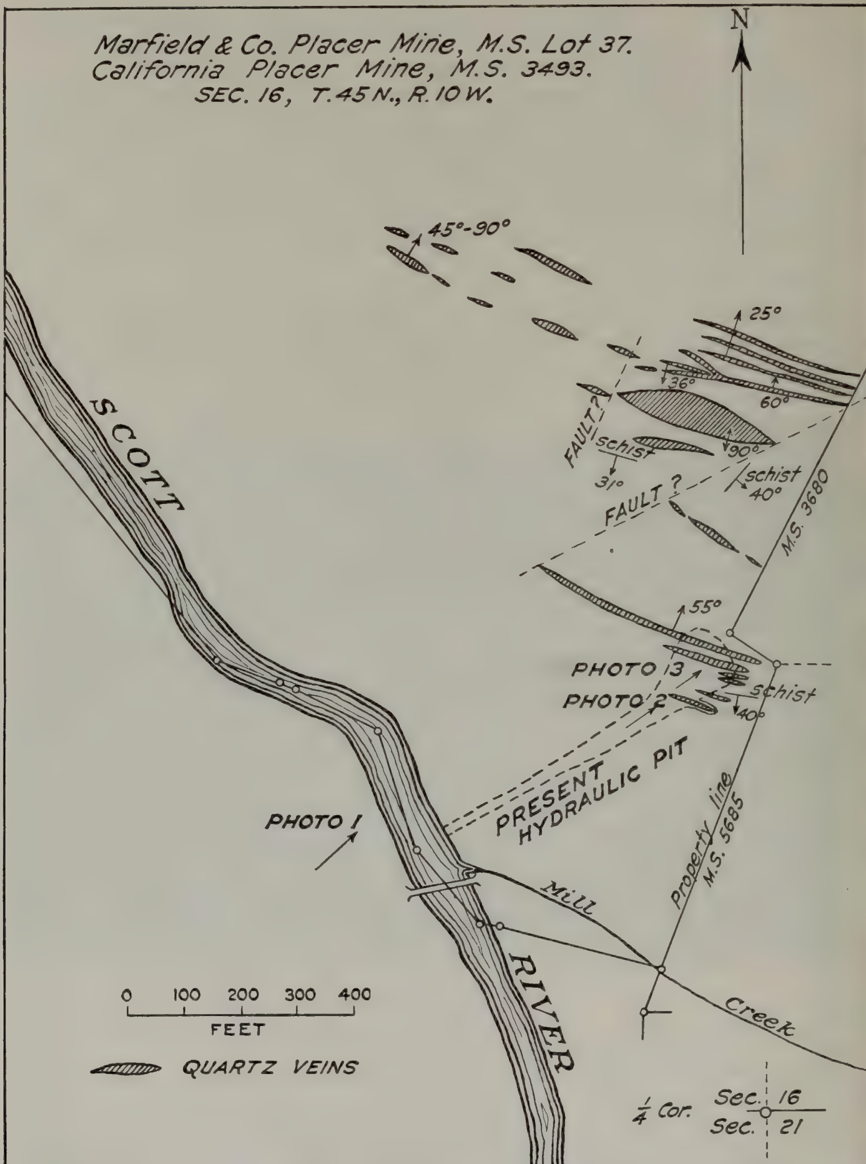


FIG. 5. Quartz Hill Mine at Scott Bar, sketch map showing vein system. Country rock is mica-schist (pre-Devonian) with many quartz stringers.

At the present time, there is a chunk, eight or ten inches long, composed entirely of gold and telluride of gold and silver (sylvanite), from this mine, on exhibit in the county recorder's office in Yreka. This came more than a year ago, from a pocket that is said to have produced 30 lbs. of similar material. The deposit seems to have great possibilities for working on a large tonnage basis; but an extensive campaign of development work, with probably test-runs in a pilot mill, will be needed to determine whether or not this can be successfully done.

Water is taken from Scott River by means of a ditch, seven miles long, with a capacity of 1500 miner's inches, and a head at the mine of 225

Quartz Hill Mine. General view of deposit. Scott River in foreground.

feet. There is no interruption in the supply of water in the dry season. A giant with a 5-inch nozzle is used in the pit, one with $4\frac{1}{2}$-inch nozzle at the head of the sluice, and one with $4\frac{3}{4}$-inch nozzle to wash the tailings down the river. Present operations are roughly 25 or 30 ft. higher in elevation than the river. For drilling with the jackhammers, an 8-in. by 9-in. Ingersoll compressor driven by water power furnishes the air.

Quartz Hill Mine. Two views of present workings.
(Photo No. 2, upper; No. 3, lower.)

Bibl: State Mineralogist's Reports VIII, pp. 622, 623; XI, p. 447; XII, p. 290; XIII, p. 421; XIV, p. 839; XXI, p. 483.

Renown Group (No. 25 on map) in Sec. 14, T. 41 N., R. 7 W., is a group of 24 claims held by Fred Gould and James F. Furlong of Gazelle. A 6-ft. shaft has been sunk on one foot of quartz showing some chalcopyrite, and stained by copper minerals derived from oxidation of this chalcopyrite. Walls are diorite or granodiorite. A 90-ft.

tunnel is being driven from a point on the hillside below to tap the vein found in the shaft. When examined the face of this tunnel was in silicified granodiorite showing specks of metallic sulphides.

Ruby Pearl Mine is in Sec. 4, T. 38 N., R. 5 W., on Castle Creek west of Castella. Gold has been produced from this mine by G. A. Larsen, who is leasing the Altoona quicksilver mine. It was idle when the district was examined, and was not visited.

Schroeder Mine (No. 26 on map) in Sec. 17, T. 45 N., R. 8 W., is assessed to M. C. Beem and others of Fort Jones; but it has recently been reported sold to the Fidelity Metals Corporation. V. O. Bartoo is in charge, with I. B. Scrimger as mining engineer. The mine address is Fort Jones. The property is seven miles in an air line west of Yreka, and is reached over the old road to Fort Jones, which crosses a summit near the Mt. Vernon mine at an elevation of more than 5000 feet. Turning from this road at Deadwood Creek, the road to the mine starts climbing the mountain, and is very steep and winding for 3½ miles. In 1895, at least five veins, or possibly faulted segments of veins, had been exposed on this property; and thousands of feet of development work had been done from adits at several different elevations on the steep side of the mountain. Ore was being treated in a ten-stamp mill operated by steam power at the rate of 12 to 13 tons per 12-hour shift. In 1927, the Sterling Gold Mining Co. did some work here; but very little ore was produced.

At the time of visit, an old tunnel on a vein called the Snowflake had been cleaned out and retimbered, so that the vein was exposed for a length of 100 feet. A width of 7 to 8 feet of shattered quartz heavily stained by iron oxides, has a strike of N. 80° E., and dip of 60° to 75° to the south. The operators stated that this gives an average assay of $8.80 per ton in free gold. The mill tunnel, called the 1600, is at an elevation 350 ft. below, measured vertically. The name '1600' comes from early-day measurements taken on the surface of the ground from some higher adit. When visited, this main level was 2000 ft. long, and was being driven ahead on a course of S. 45° W. to cut the Snowflake vein. The tunnel had just passed through a quartz stringer zone, which carried some gold; and work was to be done on this later. A compressor driven by power from the lines of the California-Oregon Power Co. was being used on this work. The 10-stamp mill was not operating.

Country rock is largely greenstone which has been highly altered. Some fine-grained granitic-appearing rock with crystals only about a millimeter in diameter was observed near the office, and some of possibly the same much silicified near the portal of the main tunnel. A dioritic intrusion was observed at a point higher on the mountain. The geology is somewhat complicated here; and apparently a complete geological examination would be of great benefit. This will require first the preparation of a good map on a large scale, based on a transit survey, of the surface and such workings as are open. With surface and underground exposures of veins, faults and formations carefully plotted and projected on such a map, a much better understanding of the vein system would result.

Sterling Gold Mining Co., see Golden Eagle and Schroeder.

Strode Mine (No. 27 on map), in Sec. 8, 9, T. 37 N., R. 7 W., near Carrville, is owned by the Strode Mines Company, 626 Fourth Ave., Milwaukee, Wisconsin. Nothing but assessment work has been done at the mine for several years. Two thousand tons of tailings from the 10-stamp mill have recently been treated with cyanide by Geo. W. Paymal of Carrville. Four cylindrical tanks, equipped with canvas and burlap bottoms, are used as leaching vats. A horse-drawn scraper is used to charge 20 tons of tailings into each of these; and a leaching solution of a strength of 4 lb. of cyanide per ton of solution is applied. Average assay values of the tailings is $3.30 per ton.

Bibl: State Mineralogist's Reports XII, p. 313; XIII, pp. 458, 459; XIV, p. 896; XVIII, pp. 207, 257, 600; XX, p. 182. U. S. G. S. Bull. 530–D, p. 35.

Sugar Creek Mining and Milling Co., see Hathaway.

Superior Consolidated Mines Co., see Johnson and Lewis, Morrison and Carlock, and New York.

Swedish American Mining Co., see Commodore.

Thomas Property (No. 28 on map), is held by Neal Thomas, address Coffee, Trinity County. The mine is at Big Flat near the trail that leads to the Yellow Rose mine. Some production of gold has been made with a two-stamp mill. It was not visited during the present survey.

Trinity Bonanza King, see Bonanza King.

Three Peaks Prospect, a mile below the lower camp of the Nash, near the road up Coffee Creek built by the MacNamara Mining Co., is held by Heninger Brothers, address Coffee, Trinity County. It has been metioned to the writer as a very good prospect, and would have been visited if a little longer field season had been available.

United Trinity, see Bonanza King.

Wagner Mine, in Sec. 34, T. 38 N., R. 8 W., was described in considerable detail by MacDonald.[30] Fissure veins are associated with lamprophyre dikes in granodiorite; and a serpentine contact is nearby. Nothing has been done here recently with the exception of treating tailings. The same cyanide equipment was used that is now at the Strode.

Williams Prospect. R. D. Williams of Callahan holds a prospect in Sec. 32, T. 40 N., R. 9 W., eight miles from Callahan, the last 2½ miles being trail. It is close to the divide between Grizzly Creek and Wildcat Creek at an elevation of 6000 feet. The writer did not visit this prospect; and the following description was given him by the owner. A vein, 20 to 24 inches wide, consisting of quartz and oxidized sulphide containing gold, and assaying $7 per ton, is developed by a drift 70 ft. long. Another vein at a right angle to the first is 10 inches wide, and is developed by a 100-ft. tunnel and a 12-ft. winze. A concentrating test on a cut sample is stated to have given the following results: heads $39.89 per ton, concentrates $552.89 per ton, tails $2.65 per ton. Concentrates were about 6% by weight of heads.

[30] MacDonald, D. F., *op. cit.*

A production of $7,000 to $8,000 is said to have been made with an arrastra.

Yellow Rose Mine (No. 29 on map), in Sec. 20, T. 37 N., R. 9 W., is the property of McCormick-Saeltzer Co., D. V. Saeltzer and R. A. Saeltzer of Redding, Clifford Saeltzer and Dorothea Sutton of San Francisco, and J. C. Boddicker of Carrville. It comprises the patented Yellow Rose of Texas, U. S. Mineral Survey 3780, 14.91 acres; Yellow Rose mill site, 5 acres, and the Red Rose and Friendship claims. One can now ride to within four miles of this group over the very rough road built by the McNamara Mining Co. to the Nash mine. The last four miles are over a mountain trail. The Yellow Rose and the Dorleska are on the same system of dikes and veins, located on the divide between Salmon River and Coffee Creek, at an elevation of 6500 to 7000 feet. Main workings of the Yellow Rose are on the south side of this divide and those of the Dorleska on the north side. In 1912, MacDonald[31] described this deposit as a serpentine mass cut by large and small lamprophyre (camptonite and kersantite) dikes. A 50-ft. dike, strike N. 16° E., dip 75° W., cuts the serpentine near the schist contact, and parallel to it; and a fault zone is also parallel. MacDonald says, "Near the Yellow Rose mine the east side of this dike contains hornblende prisms and is the 'crow's foot porphyry' of the prospector. The west side shows biotite and some quartz. * * * The ore deposits of these mines are similar. The fault zone is mineralized along the footwall of the composite dike, which is also locally mineralized where cut by side fissures. Rich shoots of clayey material which dip 45° N., characterize some of the fissure intersections."

Harry M. Thompson of Redding, who holds an option on the Yellow Rose, has two men at work on the property. This work is being done with the idea that the 'clayey' ore mentioned by MacDonald is the result of fault drag from quartz veins in the dikes. It is thought that former operators followed the line of least resistance with development work, and kept in the soft material, leaving the dikes, which are silicified and extremely hard, as an unbroken wall on one side of the working. New development work will break into these hard dikes in an effort to find the ends of quartz veins that have been sheared off by the faulting. Thompson states that since the visit of the writer to the mine, these ideas have been proved correct; and ore has been found in one of the dikes.

At the time of visit, a tunnel about 200 ft. higher in elevation than the mill level was being opened. At the 600-ft. point in this tunnel there is a good exposure of a dike, strike due N., dip 81° W., in contact with the serpentine. The tunnel has apparently followed this contact for some distance; but it is so tightly timbered that this cannot be well observed. Twenty-five feet to the east a second dike is seen in contact with the serpentine; and the gouge on this contact is said to pan gold. Preparations were being made to follow this contact with a drift toward the Dorleska. All of the workings of the latter are closed by caving. An old 3½-ft. Huntington mill, which was driven by steam, stands on the Yellow Rose property.

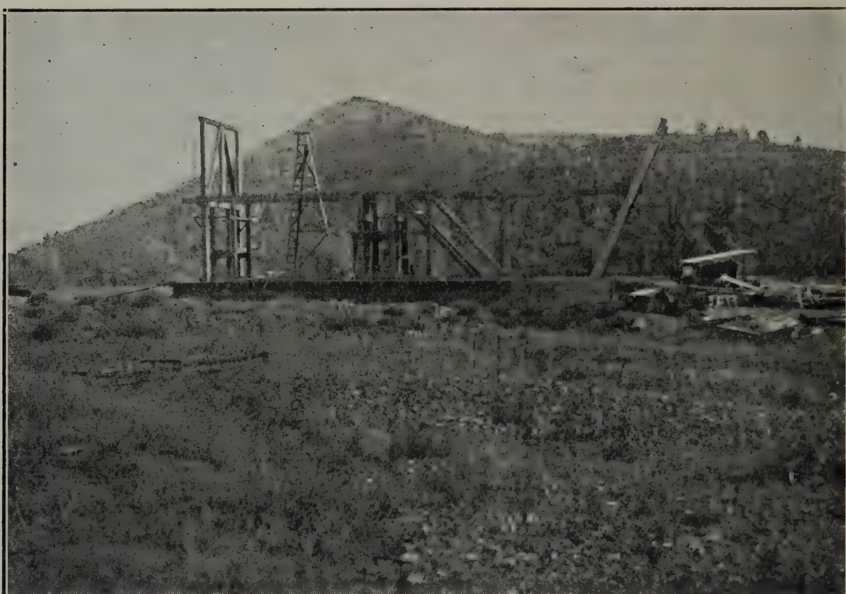
Bibl: State Mineralogist's Report XXII, p. 26.

[31] MacDonald, D. F., *op. cit.*

Gold (Placer)

Placer mining is not very active in the Shasta quadrangle at present. The following list includes only a few mines at which some recent activity has been noted by the writer. For a more complete list of placer mines of this section, the reader is referred to State Mineralogist's Report XXI, chapter published October, 1925, copies of which may be obtained at offices of this division for 25c each.

Blue Channel Mine (No. 30 on map), in Sec. 19, T. 48 N., R. 9 W., on Elliott Creek, comprises 60 acres held by Joe and Henry Slotik, address Copper, Oregon. Medford, Oregon, is about 50 miles distant. The first 13 miles, Medford to Ruch, is good oiled road, the next 18 miles to Copper is a fair, winding, narrow, dirt road, the next 4 miles to Joe Bar is similar; then the balance of the distance to the mine is trail,



Small dredge under construction a mile south of Yreka on land owned by Howard Brown of Yreka.

15 or 20 miles depending upon the route. A summer road (Forest Service) leaves Klamath River near Gottville. From here it is 26 miles across the Siskiyou Mountains to the head of Elliot Creek; and the mine is reached over four miles of trail. Three claims are held, the Hope at the confluence of Ward's fork and Silver fork of Elliot Creek, and two Blue Channel claims a mile farther up Ward's fork. The first discovery on the creek was made about 1852; and the gravel was largely mined out in the years from 1852 to 1870. The only sections of the gravel in the creek that remain unworked are those covered with slide rock of mica schist from the steep slides of the canyon, and deep deposits that accumulated in ponds behind slides. The three claims cover a total of 4500 ft. in length along the deposit, which is gravel and washed boulders of schist with some quartz. Boulders weighing

a ton are common; and fir trees three feet in diameter are growing in the slide rock and gravel. On the Blue Channel claims the gravel is mined from drifts, loaded in wheelbarrows, and washed in a 1-ft. sluice, 30 ft. long. A new sluice and 'self shooter' were under construction at the time of visit. The sluice is 100 ft. long, 3 ft. wide and 2 ft. deep; and the shooter dam is 12 ft. high and 15 ft. long; and the gate is 3 by 3 feet. This discharges as often as the reservoir fills, giving a rush of water for washing the gravel and carrying the tailings down the stream. The flow of the stream is about 10 gal. per second in the spring. Only about 30 feet of drifting has been done here, from a crosscut tunnel 40 ft. long. The gravel is 50 ft. wide at the bottom of the channel and 12 to 30 ft. deep with 15 to 20 ft. of slide rock covering it. The gold is in the lowest foot and the bedrock schist, some of which is hard and some decomposed and soft. Slotik Brothers, who are working the property, say that the channel on the Hope claim was drifted for a length of 125 ft., 15 years ago; and the yield was $3,200. Last year a length of 108 ft., drifted 12 ft. wide and 6 ft. deep yielded $1,200. The gold is all in the lowest foot and the bedrock here also. The best values are found in the bedrock where it is soft. The gold is all coarse, nuggets weighing an ounce being found on the Hope claim. A number of nuggets worth from $5 to $7 each were shown the writer. One weighing 11½ ounces is said to have been found about a claim-length below the Blue Channel claims. The concentrates that accumulate in the sluices contain a noticable amount of cinnabar.

Fawcett Mines Co., formerly called Pennsylvania, (No. 31 on map) in Sec. 22, 23, T. 48 N., R. 10 W., is being worked by S. K. Hine and L. B. Miller as trustees, address 924 National City Bank Building, Cleveland, Ohio. B. C. Fawcett, Copper, Oregon, is in charge of the work. The road from Medford, Oregon, to Joe Bar has been described under Blue Channel (which see). From Joe Bar, the Fawcett Mines are reached over 12 miles of trail up Elliot Creek. A summer road (Forest Service) leaves Klamath River near Gottville, from which it is 26 miles by mountain road across the Siskiyou mountains to the head of Elliot Creek. From here it is eight miles by trail to the mine. The property comprises 10 claims and a fraction, 210 acres, covering 14,250 ft. on the channel. The deposit consists of an accumulation of gravel behind a schist slide, which dammed the stream. Width is 40 ft. and depth 50 feet. The material is schist gravel and boulders up to 3 ft. in diameter. In the schist slide rock, 10-ft. boulders are found. Bedrock is soft schist, which strikes north and south, and dips west; and the course of the channel is also west here. The present sluice is 600 ft. long, 32 inches wide by 30 inches deep, and was installed in a bedrock cut at the toe of the big schist slide. Later it was found that the slide had changed the course of the stream, and that the sluice is too high to work the gravel in the old channel. At the time of visit a self-shooter was being built to be used for washing out the slide to lower the sluice. Elliot Creek and Cottonwood Creek are used for water supply. A by-pass flume, 2100 ft. long, 7 ft. wide and 32 inches deep, carries the flow of Elliot Creek with a depth of from 3 to 4 inches of water. The grade is 2½ inches to 12 feet. From Cottonwood Creek, 3000 ft. of 16-inch pipe supplies a No. 3 giant (4 or 5-inch nozzle) with water

under a head of 225 feet. This pipe cost $1.20 per ft. in place. The season on the water for the giant is eight months. Other equipment includes a sawmill with a capacity of 8000 bm. ft. in eight hours, and a $3\frac{1}{2}$-kw. generator for lights. Water is supplied the generator through a 5-inch pipe under a head of 150 feet. Twelve men were employed in the summer of 1930.

Small remnants of high terrace gravels occur at three different elevations in this vicinity. The boulders in these are largely greenstone, granodiorite and various porphyries; and the wash presents a very different appearance from that in the present stream which is derived largely from the Abrams schist. Fawcett states that the gold from these higher gravels is worth $18.50 per ounce; while the pocket gold found in the schist is worth $16.75 per ounce. He thinks that the higher-grade gold predominates in the present stream gravels, and that it has been concentrated largely from old channels, glacial wash, and formations that have been eroded from above the schist, rather than from pockets in the schist.

Herndon Mine (No. 32 on map), in Sec. 17, T. 46 N., R. 7 W., is owned by A. C. Herndon of Hornbrook. This is a gravel deposit on Klamath River that extends to some depth below the bottom of the present stream. A recent attempt has been made to work this by means of an open pit and power shovel. Gravel was hoisted up an inclined skip-way and washed in a sluice above. A small pump and gasoline engine handled the seepage into the pit from the river, and kept the workings free of water. The method was found too expensive; although the operators stated that recovery, including cleaning of the bedrock, averaged 40c per cubic yard. After working in this way for a short time, the same persons attempted to consolidate the property with adjoining acreage large enough to justify the installation of a dredge. These negotiations were not successful. Recent reports indicate that the richest part of this deposit, near the bedrock, is to be mined by drifting.

Holland Mine (No. 33 on map) on the East Fork of Coffee Creek was operated by Patrick Holland for more than fifty years, working either alone or with a single helper. The deposit is gravel, 25 ft. wide and 30 ft. deep, in the bottom of the steep and narrow canyon in which the creek flows; and it contains many large boulders. Bedrock is hard and irregular, and consists of serpentine and intruded dikes. Holland used a 'self-shooter,' which is an automatic gate in a dam that discharges each time the reservoir fills, giving a torrential flow for a short period to wash the gravel through the sluices. His reservoir held five acre-feet, and discharged every half hour. The season was from March to November, the property not being operated during the winter, when there are heavy falls of snow. Three quarters of a mile of the creek produced $60,000.[32]

[32] Logan, C. A., State Mineralogist's Report XXII, p. 46, 1926.

Holland Mine. Holland's 'self-shooter'.

Seymour Placer Gold Mines, Ltd., Arthur V. Seymour, president, 921 Birks Building, Vancouver, B. C., spent a large sum of money in equipping this Holland property in 1928–29, with A. C. Gardé in charge. The patented SE. $\frac{1}{4}$ Sec. 17, T. 38 N., R. 8 W., was acquired with mining locations adjoining to make a total of 846 acres, covering six miles of the stream. A camp was built a mile and a half below Holland's old workings; and nearby a giant, derrick, power plant, and other equipment were installed. This camp is half a mile from the road to the Nash mine, which crosses Coffee Creek near the point where the East Fork flows into it. A wide trail, over which a two-ton Caterpillar tractor pulled a trailer, connects the camp with the road. A mile of flume, 36 in. by 38 in., with a capacity of 50 cu. ft. per sec., or 2000 miner's inches, giving a head of 720 ft. at the giant, was built at a cost of \$9000 to \$10,000. Lumber for this was sawed in a mill above, owned by the company, and supplied with water power through a mile of flume, 12 inches square in section. A 12-inch giant (nozzles $3\frac{1}{2}$, 4 or 6 inches), capable of withstanding the 720 ft. head, was mounted on a concrete foundation, and connected with the penstock at the flume with 1400 ft. of steel pipe, starting at 36-inch, 12 gage, and reducing in steps to 12-inch, with metal $\frac{1}{4}$-inch thick, at the giant. Other equipment included 200 ft. of sluice, 7 ft. 4 in. wide and 5 ft. deep, with steel rails for riffles, 210-cu. ft. duplex compressor, 6 in. by 8 in., driven by 18-inch Pelton wheel of 75-hp., double-drum winch

driven by a duplicate Pelton wheel, and a 4½-kw. electric generator driven by a 12-inch wheel.

After the giant was installed, it was apparently realized that the installation was not flexible enough to work the narrow deposit in the bed of the stream; and a new self-shooter was built half a mile above. The dam is 100 ft. long on top; and the gate is 6 ft. wide by 13 ft. high. During the season 1929–30, gravel was washed amounting to 40,000 or 50,000 cubic yards. The cleanup was apparently disappointing; and the property is now idle.

MacNamara Mining Company, see Nash.

Mattoon Mine (No. 34 on map), 60 acres, in Sec. 34, T. 45 N., R. 9 W., on Indian Creek, is the property of R. A. Mattoon of Fort Jones, who also owns a patented claim, the New Hope, of 19.32 acres in the adjoining Sec. 3, T. 44 N., R. 9 W. Terrace gravels of Indian Creek on a bedrock of greenstone or Copley meta-andesite occur at an elevation of about 50 feet above the present stream. Hydraulic equipment consisting of 560 ft. of 11-inch pipe and a giant with a 2-inch nozzle is used during the wet season to wash this gravel. Two men are employed.

Nash Mine (No. 35 on map), divided into the Upper Nash and the Lower Nash, is on upper Coffee Creek, in T. 38 N., R. 9 W., in the gravels of the present stream. For several summer seasons, the MacNamara Mining Company, J. L. Joseph, president, Mills Building, San Francisco, has attempted to make this deposit pay by mining with steam shovels. The upper layers of gravel are stripped off first; then the lower gravel is shoveled out and washed. Only a small amount of water is available at present; although former hydraulic operations here utilized 3000 miner's inches from South Fork of Coffee Creek and Abrams Creek. No work is done in the winter. To get the shovels to the deposit, the road was continued up Coffee Creek from a point near Coffee and the Golden Jubilee mine. The surface of this road has not been improved; it is very rough. However, one can now drive to Big Flat on the divide between Coffee Creek and Salmon River, which was previously accessible only by trail.

Bibl: State Mineralogist's Reports XIII, p. 464; XIV, p. 911; XXII, p. 43.

Pennsylvania, See Fawcett.

Quartz Hill, see under lode mines.

Seymour Placer Gold Mines, Ltd., see Holland.

Lead

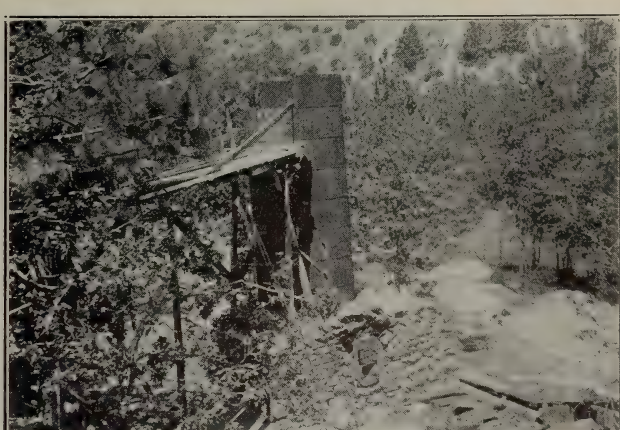
Siskiyou Lead Mine (No. 36 on map), the patented NE. ¼ Sec. 29, T. 41 N., R. 7 W., 15 miles west of Gazelle, is the property of M. H. Balfrey of Gazelle. Evans and Mitchell were leasing at the time of visit. A crosscut adit cuts the vein at a distance of 70 ft. from the portal, giving a depth of 35 feet. Galena shows in spots in a vertical mineralized zone reaching a width as great as 12 ft. in places. A drift has been driven on this for 100 ft. Two shafts on the vein, reaching to depths of 50 ft. and 80 ft. below the surface were full of water to the

tunnel level. Lessees state that 600 tons of ore on the dump assay 8% lead, 2% zinc, and $1.50 per ton in gold. The country rock is andesitic, some of it coarse enough in grain to approach diorite. A small mill manufactured by the Sacramento Gold Mill Co. was being installed. It consists of four stamps, of about 35 lbs. each, mounted on springs to give force to the blow. A jaw crusher, 6 in. by 8 in., will crush the feed for the mill. There are also two concentrators, 5 ft. by 7 ft., similar to Wilfley tables, but made by the same company as the mill. A 30-hp. gasoline engine will drive the outfit.

Limestone and Marble

Limestone is abundant and widely distributed in the west-central part and in the southeastern corner of the Shasta quadrangle; and

Devonian limestone (Kennett formation), four miles west of Gazelle. Photo by O. P. Jenkins.



Lime kiln, four miles west of Gazelle. Photo by O. P. Jenkins.

some of it has been metamorphosed to marble. The accompanying map, showing areal geology, gives a good idea of the abundance of this mineral in the quadrangle. Judging from its appearance only, it is of good quality; but no samples were collected by the writer for analysis. The only commercial utilization is at a small quarry and kiln, four miles west of Gazelle, where a few tons are burned occasionally. In this quarry remnants of Devonian fossils are rather numerous. Plans of this division call for the early preparation of a special bulletin on limestone; and further details will be given in it. A. S. Hathaway, Etna, and W. J. Chastain, Gazelle, are producers.

Manganese

Manganese prospects have been reported from Sec. 9 or 16, T. 44 N., R. 8 W., southwest of Yreka; Sec. 15, T. 46 N., R. 6 W., six miles southwest of Klamathon; Sec. 20 and 21, T. 43 N., R. 9 W., on the ridge north of Greenview and southeast of Oro Fino; and in T. 39 N., R. 11 W., near the head of Callahan Gulch. For further particulars the reader is referred to California Division of Mines Bulletin 76, 'Manganese and Chromium,' published in 1918.

Mineral Water

The numerous well-known mineral springs of this vicinity, Shasta Springs, Warmcastle Soda Springs, Klamath Hot Springs, Neys Springs, Garretson Springs, Upper Soda Springs, and many others, have been described in detail in the references given below. The ones named, except Klamath Hot Springs, are cold, carbonated springs. Principal locations are near Beaver Creek, near Ager, and in the southern part of the quadrangle near the Sacramento River. During the present survey, the writer observed a cold soda spring a few miles east of the Altoona Quicksilver mine, high in the mountains.

Bibl: State Mineralogist's Reports XI, pp. 449, 452; XIII, p. 520; XXI, p. 493. U. S. Geological Survey, Water Supply Paper 338. Winslow Anderson, 'Mineral Springs of California.'

Platinum

Black sands, which accumulate in the sluices at placer mines in this quadrangle, usually carry metals of the platinum group, including iridium. The platinum is, no doubt, derived from the erosion of serpentine; and it is likely to be more abundant in drainage basins where masses of this rock occur. There is always more or less interest in methods of recovering this platinum; but production has been small.

Bibl: State Mineralogist's Reports XXI, p. 494; XXII, pp. 64, 200; Bull. 85, 'Platinum and Allied Metals in California.'

Pumice

Within the Shasta quadrangle, no pumice has come to the attention of the writer; but it is almost certain that deposits can be found in the large areas of volcanic formations. To the east of the quadrangle, on the slopes of Mt. Hoffman, E. L. Jameson of Redding has a deposit of pumice.

Bibl: State Mineralogist's Report XXI, p. 495.

Quicksilver

Altoona Quicksilver Mine (No. 37 on map), in Sec. 22, 26, 28, T. 38 N., R. 6 W., 24 miles by road west of Castella, is owned by the Altoona Quicksilver Mining Co., J. Frowenfeld, president, Room 1406, 315 Montgomery St., San Francisco. The steep road to the mine crosses the mountains at an elevation of nearly 6000 ft.; and the property is at an elevation of 4500 feet. This old mine is credited with a production of about 29,000 [33] flasks of quicksilver, largely in the years from 1875 to 1902. It was worked by a shaft and winze to a depth of 600 ft. below the surface. A heavy flow of water was encountered on the lower levels; and pumping was expensive.

At present G. A. Larsen of Castella is leasing the mine. The shaft has been retimbered to the 45-ft. level (Fig. 6); and a drift has been driven ahead for 110 feet. This developed a vein containing cinnabar,

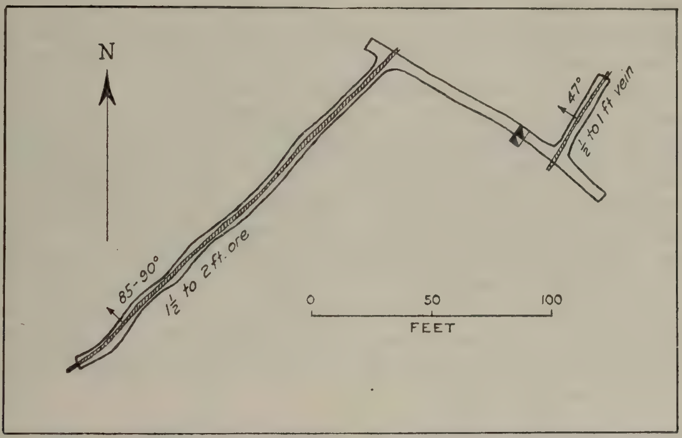


FIG. 6. Altoona Quicksilver Mine, sketch map showing veins on the 45-ft. level of the shaft, the present working level. Country rock is a complex of gabbro and serpentine, introduced by various dikes, the whole much altered near the veins.

which is being stoped for a length of 75 ft. and a height of 20 ft. above the level. The vein is from 18 inches to 2 ft. in width; and parts of it yield ore running 1¾% mercury. The remaining 20 ft. on this will be stoped; and the shaft will be retimbered to reach it from a lower level. At the time of visit (August, 1930), the water stood at 100 ft. below the 45-ft. level. A second vein, 6 inches to a foot wide, has been followed for 40 ft. from a point 15 ft. from the shaft on the opposite side. This drift will be continued to reach a place where ore has been found above on the surface.

The ore being mined at present is soft, decomposed material, stained brown by oxides of iron; and no powder is used to break it. Picking alone is used to remove the ore; and the harder walls stand well, with only a few small stulls for support. A 2-cylinder steam hoist of 80 hp. is used to raise the ore cars on a cage. Treatment is in a Knox furnace of eight tons capacity in 24 hours. Average consumption of wood is 1¼ cords per day at $6 per cord. The furnace is run continuously; but

[33] Bradley, W. W., Quicksilver Resources of California: Cal. State Min. Bur., Bull. 78, p. 201, 1918.

the hoist is not run every day. Five men were working, one on top, two in the mine, and two shifts of one man each on the furnace. Production for 1929 was 100 flasks, and that for 1930 to date of visit 55 flasks. An additional production of 100 or 150 flasks was expected for 1930.

Bibl: State Mineralogist's Reports IV, p. 336 (Table); VIII, p. 643; X, p. 716; XI, pp. 481, 482; XII, p. 371; XIII, pp. 603–604; XIV, p. 923; XXII, pp. 65–66. Chapter Rep. Bien. Period, 1913–1914, p. 179. Bull. 27, pp. 192, 219. Bull. 78, pp. 200–201. U. S. G. S. Mon. XIII, p. 366. Min. Res. W. of Rocky Mts., 1875, p. 20; 1876, p. 19.

Horse Creek Cinnabar Co., Ltd. (No. 38 on map), is purchasing from H. J. Barton of Yreka 35 acres of patented mining claims in Sec. 15, 16, T. 46 N., R. 10 W., on Klamath River road where the Horse Creek bridge crosses the Klamath. The president is Dr. A. H. Taylor, 5558 Hollywood Boulevard, Los Angeles, and the secretary is Ben Cohn, Horse Creek, Siskiyou Co., California. Mica schist alternates with bands of hornblende schist, the schistosity on the latter not being so well developed as on the former. Small amounts of cinnabar are seen on fractures in the dark-green hornblende schist; and it seems to be associated with this rock only. A mass of light-colored dioritic rock on the property also shows some schistosity. Development consists of three tunnels, 20 ft. to 30 ft. long and numerous (25 to 30) small prospect cuts on the hillside. These average 5 ft. long, 1 ft. wide and 4 ft. deep. The property was equipped with a continuous process retort with a rated capacity of 25 tons per day, which has not yet been successfully operated, because some of the metal parts failed to withstand the heat when it was first fired up. A 25-hp. Fairbanks-Morse gasoline engine furnished the power.

Integral Quicksilver Mine is a property of large acreage adjoining the Altoona. It has not been operated for years; and the buildings and other equipment are in ruins. Details of past production will be found in the references listed under the Altoona Quicksilver Mine.

Mercury Mine (No. 39 on map), formerly the J. N. P. Mining Co., or Morgan Brothers Mine, is the property of Eugene Aureguy, Room 333 Mills Bldg., San Francisco. The location is Sec. 13, 14, 24, T. 47 N., R. 8 W., near Gottville or 21 miles from Hornbrook. The first 16 miles are improved highway along Klamath River; and 5 miles are unimproved mountain road. A total of 250 acres are held, also a water right in Sec. 18, T. 47 N., R. 7 W. A fissure vein striking S. 70° W., and dipping 55° to the northwest carries cinnabar and native mercury in a gangue of quartz and calcite. Country rock is schist formed from metamorphosed sediments intruded by granodiorite; and the ore seems to be associated with the contact between these two rocks. However, faulting is in evidence; and the possibility exists that the mineralization has come up along this from younger intrusive rocks below. Less than 10 miles to the east, Tertiary volcanic rocks are exposed on the surface. A stope, 100 ft. long, was being made on the vein mentioned above, with a width of 5½ ft. average, 12 ft. maximum, and a height of 20 ft. above the main level. A raise of 140 ft. on the

vein connects the top of this stope with the surface. This main level is an adit, from which several hundred feet of work, drifts and crosscuts, have been done. A second adit, from which several hundred feet of work have been done, is about 50 ft. above and 500 ft. to the east of the main adit. Some ore is exposed here also.

The property is equipped with a flotation plant of a capacity of 24 tons per 24 hours. A crusher, 10 by 12 in., reduces the ore to one-inch size; and this is fed to a 15-ton (rated capacity) ball mill by an automatic feeder, and is here reduced to 40-mesh. This product is treated in three Kraut flotation machines; and concentrates are retorted in Hendy pipe retorts, six pipes, 12 inches by 6 feet, with oil as fuel. An attempt is made to recover native mercury at the discharge of the ball mill on copper plates. A 75-hp. Holt gasoline engine runs the plant. Mine equipment includes a compressor of one-drill capacity, rails and cars. W. W. Young of Gottville is superintendent; and six men are employed.

Bibl: State Mineralogist's Report XXI, p. 496; Bull. 78, p. 169.

Stone

Several varieties of building stones are found in this vicinity, marble, granodiorite, sandstone, and all colors and shades of lavas and tuffs. Sandstone has been used in some of the county buildings at Yreka. Buildings of lavas and tuffs may be seen at Mt. Shasta City and Weed. The rocks are crystalline; and the different natural colors and shades, when used together, give very pleasing effects.

SACRAMENTO FIELD DIVISION

C. A. LOGAN, Mining Engineer

Mr. C. A. Logan, District Engineer, has been engaged during the past three months in the preparation of a special report upon the Mother Lode of California, which will be published during the current year.

SAN FRANCISCO FIELD DIVISION

C. McK. LAIZURE, Mining Engineer

Reports covering the mines and mineral resources of all of the counties in the San Francisco field division are now available, and field work at present is confined to investigations for special reports upon various economic minerals.

LOS ANGELES FIELD DIVISION

W. B. TUCKER, and R. J. SAMPSON, Mining Engineers

A survey in connection with a special report upon Feldspar and Silica in California, not yet completed, has comprised the field work of the Los Angeles division during the past quarter.

GEOLOGIC BRANCH

OLAF P. JENKINS, Chief Geologist

RECORD OF PROGRESS BY FEDERAL DEPARTMENTS

Topographic Maps Available.

Good topographic maps are fundamental to geological surveying as well as to many other types of study. The writer has prepared, therefore, an index map showing the areas which are covered by all available topographic maps of any noteworthy importance. By use of different arrangements of ruled lines, the various maps are graphically classified as to scale and source of publication.

Work of the U. S. Geological Survey in California.

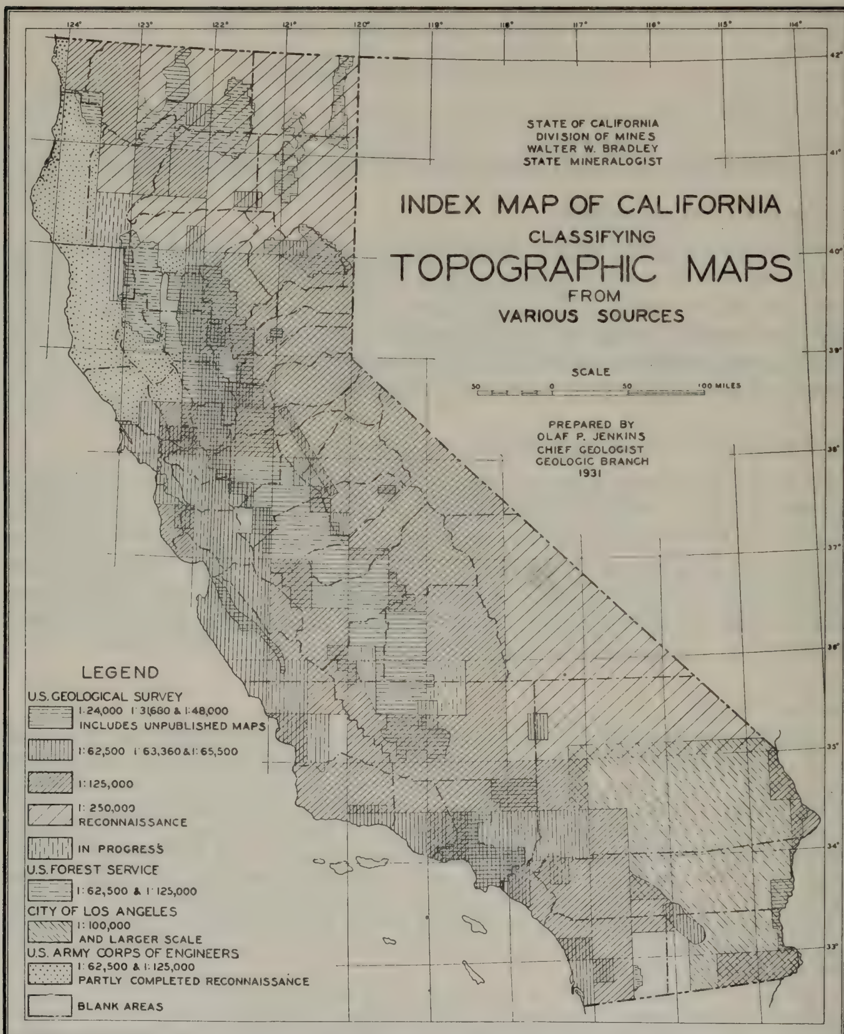
In the Fifty-first Annual Report of the Director of the Geological Survey, United States Department of the Interior, Dr. George Otis Smith (Director since 1907) summarizes the progress of the Federal Survey for the fiscal year ending June 30, 1930. The following paragraphs are quotations dealing with California. They are taken from this recent progress report and grouped according to the several branches of the federal organization.

Geologic Branch.

"Additional field work near Barnwell, Searchlight, Nipton, and Kelso was done by D. F. Hewett in connection with his study of the geology and ore deposits of the Ivanpah quadrangle. Some progress was made on the report by Adolph Knopf on the copper deposits of Plumas County. A paper by Professor Knopf on certain of the problems involved has been published in Economic Geology. F. E. Matthes resumed work on his report on the geomorphology of the upper San Joaquin Basin. Field and office studies of the San Andreas rift were continued by L. F. Noble, partly in cooperation with the Metropolitan Water District of Southern California. A brief report was prepared for the district to aid it in determining the geologically most favorable places to cross the San Andreas fault zone with proposed aqueducts from the Colorado River.

"Work at the Lassen Volcano Observatory, at Mineral, in charge of R. H. Finch, consisted of continuous operation of seismographs at Mineral and Viola, observations of temperatures of the hot springs, measurements of movements in the land-slip areas, and studies of certain of the flows in Lassen Volcanic National Park.

"Manuscripts for reports on the geology and oil resources of the Elk Hills, by W. P. Woodring, P. V. Roundy, and H. L. Farnsworth, and on the geology of the eastern part of the Santa Monica Mountains and adjacent areas, Los Angeles County, by H. W. Hoots, were transmitted for publication; also a paper on names and definitions of the geologic units of California, by M. Grace Wilmarth. The Devil's Postpile and its strange setting are described by F. E. Matthes in an article for the Bulletin of the Sierra Club of California and some peculiar fossil forms from California and Mexico by W. C. Mansfield in the proceedings of the



In addition to topographic sheets whose locations are indicated on above index map, the following charts are available: (1) U. S. Coast and Geodetic Survey charts, covering all coast lines and islands. (2) U. S. Geological Survey charts covering detailed surveys of the following river courses—Klamath, Scott, Trinity, North and South forks of Trinity, Salmon, Pit, Smith, Eel, Feather, American, South and Middle forks of American, Truckee, Stanislaus, Tuolumne, San Joaquin, South and North forks of San Joaquin, and Colorado rivers.

United States National Museum. W. P. Woodring submitted the following short papers for publication in scientific journals:

"Tertiary deposits bordering the Simi Valley [abstract]. Proceedings of Cordilleran section of Geological Society of America.

"Upper Eocene orbitoidal Foraminifera from the Santa Ynez Range [abstract]. Proceedings of Cordilleran section of Geological Society of America.

"Pliocene deposits north of Simi Valley.

"Distribution and age of the marine Tertiary deposits of the Colorado Desert."

Publications.

Professional Paper 158–I.

W. T. Schaller—Borate minerals from the Kramer district, Mohave Desert, California.

*Professional Paper 160.

Francois E. Matthes—Geologic history of the Yosemite Valley.

Bulletin 812–D.

H. W. Hoots—Geology and oil resources along the southern border of San Joaquin Valley, California.

Topographic Branch.

"In cooperation with the State Engineer of California, the survey of the mouth of Kern, Rockpile School, Adobe Station, Millux, Conner, Bear Mountain, Waits, Edison, Bena, and West Elk Hills quadrangles and the revision of the Rosedale quadrangle were completed and the survey of the Pentland Junction quadrangle was begun. In cooperation with the County Surveyor of Los Angeles County, the survey of the Sylmar, Dume Point, Roosevelt School, Humphreys, Lancaster, Oban, Lang, Saugus, No. 7, No. 5, and Flat quadrangles was completed, that of the Del Valle quadrangle was continued, and that of the Llano, Lovejoy Springs, Casa Desierto, Wilsona and Ravenna quadrangles was begun. In preparation for geologic mapping, the survey of the Crucero quadrangle was completed. At the request of the Forest Service, the survey of the Hoaglin quadrangle was begun."

Publications.

Allensworth (350° 45′–35° 52′ 30″; 119° 22′ 30″–119° 30′).
Alpaugh (35° 52′ 30″–36°; 119° 22′ 30″–119° 30′).
Delano (35° 45′–35° 52′ 30″; 119° 7′ 30″–119° 15′).
Ducor (35° 52′ 30″–36°; 119°–119° 7′ 30″).
Famoso (35° 30′–35° 37′ 30″; 119° 7′ 30″–119° 15′).
Hacienda Ranch (35° 45′-35° 52′ 30″; 119° 30′-119° 37′ 30″).
Inglewood (35° 54′–34°; 118° 18′–118° 24′).
Pixley (35° 52′ 30″–36°; 119° 15′–119° 22′ 30″).
Porterville (36°–36° 7′ 30″; 119°–119° 7′ 30″).
Quincy School (35° 45′–35° 52′ 30″; 118° 52′ 30″–119°).
Richgrove (35° 45′–35° 52′ 30″; 119°–119° 7′ 30″).
Sausalito School (35° 52′ 30″–36°; 119° 7′ 30″–119° 15′).
State, scale 1 inch–8 miles.
Stone (35° 45′–35° 52′ 30″; 119° 15′–119° 22′ 30″).
Stratford (36° 7′ 30″–36° 15′; 119° 45′–119° 52′ 30″).
West Alpaugh (35° 52′ 30″–36°; 119° 30′–119° 37′ 30″).

Water-Resources Branch.

"Water levels were measured in selected wells in southern California under the direction of F. C. Ebert. The record now covers a period of 26 years. Work was continued, with financial support by the East Bay Municipal Utility District, on the investigation of the ground water in the alluvial fan of the Mokelumne River by H. T. Stearns, G. H. Taylor, C. A. McClelland, and L. K. Wenzel. The results of the investigation to July 1, 1929, were published as Water–Supply Paper 619. Measurement of wells in the Calaveras River area was continued in cooperation

*Published during the latter part of 1930.

with the city of Stockton. Tests of samples of water-bearing material were made by Burt Burlingame at the laboratories of the State University at Davis. A preliminary survey of the quality of surface waters was initiated. Occasional samples for partial analysis will be collected at nearly all the gauging stations to furnish data on which to base a plan for a comprehensive study of the quality of surface waters."

Publications.

Water Supply Paper 578.

D. G. Thompson—The Mohave Desert region, California, a geographic, geologic, and hydrologic reconnaissance.

Water Supply Paper 619.

H. T. Stearns, T. W. Robinson, and G. H. Taylor—Geology and water resources of the Mokelumne area, California.

Water Supply Paper 636-D.

H. D. McGlashan—Surface water supply of the San Joaquin River Basin, California, 1895–1927.

Water Supply Paper 636-E.

H. D. McGlashan—Surface water supply of Pacific slope basins in southern California, 1894–1927.

Water Supply Paper 637-A.

H. D. McGlashan—Surface water supply of minor San Francisco Bay, northern Pacific, and Great Basins in California, 1895–1927.

Conservation Branch.

"Examined 54 tracts for agricultural classification. Investigated the oil-shale resources of 1 tract in Santa Barbara County and the sodium resources of parts of 2 townships in southeastern Kern County. Supervised on public land 191 leases and 519 prospecting permits for oil and gas, 4 leases for potassium, 6 prospecting permits for coal, 15 for sodium, and 1 for potassium. Oil produced, 10,729 barrels; natural gas, 13,090,399,000 cubic feet; natural-gas gasoline, 60,647,334 gallons; coal, 62 tons; sodium borate, 7584 tons; sodium carbonate, 21,241 tons. Total rent and royalty accrued, $1,034,629.91. Supervised on naval petroleum reserves 27 leases for oil and gas. Oil produced, 6,978,922 barrels; natural gas, 6,817,-458,000 cubic feet; natural-gas gasoline, 25,567,986 gallons. Total rent and royalty accrued, $1,612,167.05. Supervised 29 power projects."

State Cooperation.

"The first Director of the United States Geological Survey, in a communication to the State geologist of one of the Mid-Western states in 1880, said:

" 'The Director desires to announce to you that he urges the inauguration and continuance of State surveys and wishes to cooperate with them to the mutual advantage of both.'

"Since that utterance of 50 years ago cooperation with State surveys has been an important element in the activities of the Federal Survey.

"Cooperation between organizations engaged in work with similar objectives needs no advocacy. The State surveys are engaged in applying geology to the service of their respective states. The Federal Survey is engaged in rendering a similar service to the United States as a whole. Staffs, equipment, and available funds differ as between different State organizations and between these and the Federal organization. Each at any particular time may be relatively strong in certain particulars and relatively weak in others, for staffs are not permanent nor of uniform quality, and there are variations in the ability and the desire of Legislatures to support the work. Obviously team work will be productive of more results, of higher quality, than isolated effort which disregards what others are doing in similar and perhaps adjacent fields.

"The active State Geologists' Association provides a medium for the exchange of ideas and experiences between the representatives of the State organizations

and thus fosters the efficiency of each. The Federal Survey, working sympathetically with the association, participates in and contributes to the exchange of ideas. It maintains direct cooperation with many of the State organizations—chiefly, to be sure, in topographic mapping and work on water resources, partly because the states are usually not equipped for work of this sort, but also because by cooperating on the cost-sharing basis the needed base maps and stream-flow records become available to the states at a great saving in cost. Geologic cooperation is also maintained, though on a less extensive scale. Because the State surveys have their own geologic staffs, large or small, they have less need for geologic aid than for aid in other branches of the work. But as the Federal survey geologic staff sometimes includes specialists in fields not represented on the staff of a State, it may be advantageous to the State to procure the services of these specialists through cooperation rather than to attempt development of such specialists on their own staffs—a process that may take several years. Again, many State geologic problems are also interstate, for State boundaries do not follow geologic boundaries. Many of these problems can be effectively attacked by cooperation between the geologic staffs of adjoining States. Others have phases that can not be solved without bringing together the evidence from broad areas over-running several State boundaries. In such problems the Federal Geological Survey may serve as a general integrating medium and thus render material aid to each State affected. Yet too often, by reason of an inadequate staff, it has not been possible for the Federal Survey to extend this appropriate and highly desirable type of cooperation to the States.

"In some States there is either no official geologic survey or else an organization with only a small staff. Such States materially augment the work which they can do alone or which the Federal Survey could do alone by inviting the national organization to undertake economic or other surveys on a cost-sharing basis. The Federal Government and the State each contributes to the cost of the work, which is done under Federal auspices and by the Federal Survey staff, the resulting reports being printed either by the State or by the Government, as may be mutually agreed upon.

"Many State geologists, past and present, have also at some time been members of the United States Geological Survey staff. This background of common experience does much to facilitate cooperation, to establish common standards, and to render the work, both State and National, of the greatest scientific and economic value."

The expenditures for cooperative work in California (fiscal year, ending June 30, 1930) were as follows:*

Topographic surveys:	
Federal	$54,918 53
State of California	54,705 46
(State Engineer, Department of Public Works)	
Total	$109,623 99
Water Resources	
Federal	*$8,016 67
State	44,899 63
Municipal	21,887 99
	$74,804 29

Geologic Map of California.

Compilation of the geologic map of California on a scale of 1:500,000, in cooperation with the Geologic Branch of the California State Division of Mines, was begun.

*Figures taken from published report of appropriations committee.

Geologic Map of the United States.

The compilation of the geologic map of the United States on the scale of 1:2,500,000 was well advanced.

Plans for the Future.

In another publication, i. e., the record of the hearings of the Survey before the subcommittee of the House Appropriations Committee in charge of the Interior Department Appropriations Bill for 1932, several matters relating to cooperative work between the Federal and State organizations relate particularly to California. This information may be summarized as follows:

1931 allotments for topographic surveys:	
Federal	$42,945 86
State of California	60,878 96
1932 estimates for topographic surveys:	
Federal	$86,000 00
State of California	110,000 00

Federal topographic field projects in California Surveys of national forests:

Surveys of national forests:	
Trinity region	1931-allotment $8,000.00
Klamath region	1932-estimate $8,000.00
Public-land surveys:	
Death Valley	1930-expenditure $4,964.64
White River No. 3	1931-allotment $5,000.00; 1932-estimate $5,000.00
Kettleman Hills district	1931-allotment $1,800.00

Federal Geologic Projects Under Way.

Geologic map of California.

Several mining geologists in mining districts of California.

Geological examination of oil resources of the Kettleman Hills.

Geology along San Andreas rift.

Geology and ore deposits of Ivanpah quadrangle, California and Nevada.

Yosemite Valley and its history. (Completed and published during latter part of 1930 as Professional Paper 160.)

Mineralogy of the potash minerals of California pegmatites.

Southern California batholiths.

Geology and geography of Death Valley.

Vulcanology of Mount Lassen at Mineral, California, and further studies of northern California.

(California station, 1930 expenditures, $638.44; 1931 allotments, $900; 1932 estimates, $2,000.)

A [illegible] d replica of the original model [illegible] plaster of Paris, [illegible] features and lettered to show counties, prin- [illegible], etc., is on permanent exhibit [illegible] Ferry Building, San Francisco.

[illegible] ages 72-73

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Water-Resources—Projects in California.

Surface water

	1931	1932
Federal needed to match	$51,500 00	$52,250 00
State and municipal	54,500 00	54,500 00

Ground water

	1931	1932
Federal needed to match	$ 5,850 00	$ 5,000 00
State and municipal	11,350 00	10,000 00

Quality of water

	1932
Federal needed to match	$4,000 00
State and municipal	4,000 00

Relief Map of California.

The new relief map of California, shown by photograph and described by Mr. H. A. Sedelmeyer in this Quarterly Chapter, is an important contribution to the study of the surface features of the State. It should be of intense interest to travelers, scientists, engineers, and students in various schools. At a glance, the major surface features are seen.

Geologically, this relief map is especially interesting. The principal structural characters of the State, such as the westward tilting of the great Sierran block, bounded on the east by a tremendous fault scarp, the Great Valley trough, the long fault valleys of the Coast Range, the intersection of these by Sierran structure and cross-structures in the south, desert mountain ranges of the southeast and in the extreme north, the lava country on the east side, and the Klamath Mountains on the west. Lakes, rivers, and peaks are clearly shown. Marysville Buttes, the remains of an old volcano, show up prominently in the center of the Sacramento Valley. The model is something that may be examined and studied with profit.

PREPARATION OF A NEW RELIEF MAP OF CALIFORNIA

By H. A. Sedelmeyer*

Introduction.

There has long been a demand on the part of engineers, power companies, railroad companies, commercial aviation companies, oil companies, motor transport companies, educational institutions and different map users for an accurate relief map of the State of California. With this in mind, the map herein illustrated was constructed by the writer. It represents approximately one year of painstaking work. It shows the relief of the State with as much detail as the scale will permit. The horizontal scale, 1 inch equals 12 miles, makes the dimensions of the model about 3½ feet wide by 6 feet long.

* Chief Draftsman, U. S. Forest Service, Region 5, Ferry Building, San Francisco, California.

Near view of relief map under construction. Mr. H. A. Sedelmeyer is shown at work filling in and smoothing off the steps produced by the cardboard forms. Each cardboard has been cut along a contour (line of equal elevation) and tacked in proper position. The interval of elevation from one to another represents in the lower altitudes, 250 feet, and in the higher, 500. The horizontal scale is 12 miles to the inch, while that of the vertical has the exaggeration of 8:1.

Two of the accompanying photographs were taken during the process of the construction, and the third represents the final form of the relief map.

The following report has been prepared in order to give some idea of the accuracy of the topography, the source of the data used, and the method employed in making the map.

Source of Data.

Topographic maps of U. S. Geological Survey, U. S. Coast and Geodetic Survey, Forest Service Survey, and city and private surveys were the chief sources of data used.

Preparation of a General Topographic Map.

As no complete topographic map of the State was available, all topographic data were collected and a contour map of the State was compiled. The compilation was laid out on the polyconic projection to the scale of 1 inch equals 12 miles. All triangulation stations were plotted and the topographic data were tied to these stations in order to assure their correct geodetic position.

Exaggeration of Vertical Scale.

A vertical exaggeration of 8:1 was adopted in order to bring out the different topographic features to a better advantage, such as the lower portions of the Coast Ranges, the traces of important faults and other interesting geologic and topographic peculiarities of the State, which can readily be seen by inspecting the accompanying illustrations.

Construction of Master Model.

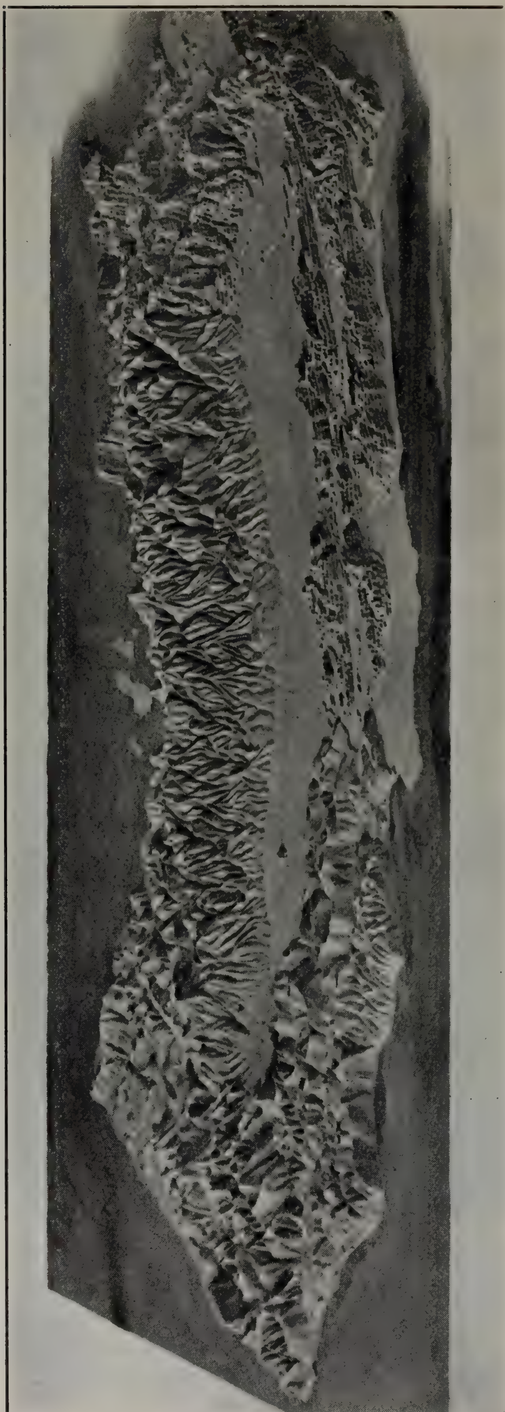
The original relief map of the State was built on a wooden base. Forms were cut from cardboard in shapes delineated by each contour line. These were nailed down, each in its proper horizontal position, one above the other from the lowest elevation to the highest, forming a step-like structure. The thickness of each cardboard form was made to represent properly the contour interval employed. For the first 1000 feet elevation the interval of 250 feet was used, while double that amount proved more satisfactory for higher altitudes. Periodic checks were made during the process of construction in order to assure the correct geodetic position of all topographic features.

After the map was completely built up in this manner, its surface was shellacked in order to prevent swelling due to moisture. The steps between the edges of the cardboard forms were then filled in and the surface of the whole map smoothed off with a French modeling clay. The original contour map served as a constant guide during this process of modeling.

Preparation of Plaster Casts.

After the completion of the master model, a negative glue mold was prepared. Any number of plaster of paris casts may be made from this negative. They are the exact replica of the original model. The surface of the casts are hardened to prevent chipping. The finished casts may be framed for wall or table use.

6—83183



Side view of relief model of California, while in process of construction. The Coast Range, indicated in the right foreground, is built up by cardboards cut along contour lines and tacked one above the other in step fashion. The rest of the area has had the steps smoothed off by a filling of modeling clay.

Replicas of the original model and photographic prints are now being used in various branches of the government service.

The writer and associates are engaged in the construction of another map of this type, on a larger scale, which will probably be completed by Jan., 1932.

OIL FIELD DEVELOPMENT OPERATIONS

R. D. Bush, State Oil and Gas Supervisor.

From September 28, 1930, to and including December 27, 1930, the following new wells were reported as ready to drill:

Company	Sec.	Twp.	Range	Well No.	Field
FRESNO COUNTY:					
Amador Coalition Mines, Inc.	26	20	14	1	Coalinga
Petroleum Securities Co.	28	20	16	Gatchell 2	Coalinga
Amerada Petroleum Corp.	29	21	17	King 1	Kettleman Hills
Standard Oil Co.	29	21	17	34	Kettleman Hills
Standard Oil Co.	29	21	17	85	Kettleman Hills
Superior Oil Co.	29	21	17	Huffman 2	Kettleman Hills
Carruthers Oil & Land Co.	4	17	20	Barritt 1	Kettleman Hills
KERN COUNTY:					
Belridge Oil Co.	27	27	20	8-27	Belridge
Belridge Oil Co.	35	27	20	48-35	Belridge
Reward Oil Co.	34	27	20	4	Belridge
Shell Oil Co.	14	28	20	Core Hole D	Belridge
Standard Oil Co.	36	27	20	McPhail 1	Belridge
Standard Oil Co.	36	27	20	McPhail 2	Belridge
The Texas Co.	22	27	20	J. D. Martin 1	Belridge
Union Oil Co.	36	27	20	Belridge 17	Belridge
Standard Oil Co.	14	25	18	Alferitz 1	Devils Den
L. C. Osborn	21	29	27	1	Fruitvale
California Star Oil Co.	22	28	27	1-40	Kern River
California Star Oil Co.	22	28	27	2-40	Kern River
California Star Oil Co.	22	28	27	4-40	Kern River
General Petroleum Corp.	26	28	27	Sill 7	Kern River
General Petroleum Corp.	26	28	27	Sill 8	Kern River
General Petroleum Corp.	26	28	27	Sill 9	Kern River
C. C. M. O. Co.	8	32	23	88	Midway
Standard Oil Co.	33	31	24	112	Midway
C. C. M. O. Co.	6	28	29	2	Round Mountain
Shell Oil Co.	20	28	29	Freeman 9	Round Mountain
Shell Oil Co.	29	28	29	Jewett 14	Round Mountain
George S. Wright	3	28	28	Glide 1	Round Mountain
Lake View Oil and Refining Co.	4	11	23	P. W. 44	Sunset
Standard Oil Co.	31	12	23	118	Sunset
Bankline Oil Co.	26	11	24	Orloff 1	
Mohawk Petroleum Co.	32	30	29	1	
Shell Oil Co.	29	30	29	Porter 1	
Superior Oil Co.	32	29	25	K. C. L. 1	
KINGS COUNTY:					
Associated Oil Co.	35	21	17	Whepley 2	Kettleman Hills
North American Oil Consolidated	36	21	17	Blauvelt 1	Kettleman Hills
Petroleum Securities Co.	35	21	17	Felix 3	Kettleman Hills
Richfield Oil Co.	36	21	17	Signal 1	Kettleman Hills
Kettleman Lake View Oil & Gas Co.	11	23	19	1	
Murphy Gas Co., Ltd.	20	23	20	1	
Thomas H. T. Purman	36	23	17	1	
LOS ANGELES COUNTY:					
Associated Oil Co.	34	3	13	De Francis 12	Dominguez
E. K. Allison Syndicate	8	2	14	Baldwin Hills 1	Inglewood
Smith Development Co.	20	3	14	Peck 9	Lawndale
Allied Petroleum Corp.	19	4	12	Garrison 3	Long Beach
Anchor Petroleum Co., Ltd.	13	4	13	1	Long Beach
R. R. Bush Oil Co.	18	4	12	Guichard 1	Long Beach
Tom J. Cannon	29	4	12	Hall-Webber 5	Long Beach
P. G. Cumming	19	4	12	D'Angelo 6	Long Beach
Dabney-Johnston Oil Corp.	18	4	12	83	Long Beach
Dabney-Johnston Oil Corp.	13	4	13	82	Long Beach
Davis Investment Co.	29	4	12	18	Long Beach
Fred G. Delaney Trust No. 1	19	4	12	Trust 1	Long Beach
Dixie Canden Oil Co., Ltd.	19	4	12	1	Long Beach
El Bar Oil Co., Ltd.	19	4	12	2	Long Beach
Enid Oil Co.	13	4	13	1	Long Beach

OIL FIELD DEVELOPMENT OPERATIONS—Continued

Company	Sec.	Twp.	Range	Well No.	Field
LOS ANGELES COUNTY—Continued					
George F. Getty, Inc.	29	4	12	L. B. 30	Long Beach
Graham-Loftus Oil Corp.	18	4	12	Maharg 1	Long Beach
Long Beach Cerritos Oil Co., Ltd.	18	4	12	1	Long Beach
M. & A. Oil Co., Ltd.	29	4	12	Masters & Daniels 2	Long Beach
M. & A. Oil Co., Ltd.	29	4	12	Painted Hills 2	Long Beach
A. H. MacFarland Syndicate	29	4	12	3	Long Beach
Malibu Signal Oil Co., Ltd.	19	4	12	1	Long Beach
Mariana Petroleum Corp.	13	4	13	1	Long Beach
Northwestern Oil Co., Ltd.	13	4	13	1	Long Beach
E. J. Preston	13	4	13	32	Long Beach
K. G. Pulliam, Jr.	18	4	12	5	Long Beach
Richfield Oil Co.	19	4	12	Bernstein 6	Long Beach
J. Orville Seeple	19	4	12	Sterling 1	Long Beach
Shell Oil Co.	29	4	12	Babb & Tucker 7	Long Beach
Shell Oil Co.	29	4	12	Cherry Hill Comm. 9	Long Beach
Shell Oil Co.	29	4	12	Hamilton 4	Long Beach
Shell Oil Co.	29	4	12	Nesa 13	Long Beach
Shell Oil Co.	29	4	12	Wells 5	Long Beach
Vesta Petroleum Co.	29	4	12	6	Long Beach
H. L. Whiston	19	4	12	Fee 1	Long Beach
Section Thirty-One Petroleum Corp., Ltd.	31	4	15	1	Newhall
York-Smullin Oil Co.	13	3	16	5	Newhall
Balboa Oil Co., Ltd.	28	2	15	1	Playa del Rey
Barnsdall Oil Co.	28	2	15	Burks 2	Playa del Rey
Barnsdall Oil Co.	28	2	15	Burks 8	Playa del Rey
Barnsdall Oil Co.	28	2	15	Burks 9	Playa del Rey
Barnsdall Oil Co.	28	2	15	Burks 10	Playa del Rey
Barnsdall Oil Co.	28	2	15	Burks 12	Playa del Rey
Beaudette Dunn Petroleum Co., Ltd.	29	2	15	1	Playa del Rey
Bergman-Albright Oil & Gas Co., Ltd.	21	2	15	3	Playa del Rey
Beverly Hills Petroleum Corp.	28	2	15	2	Playa del Rey
Beverly Hills Petroleum Corp.	28	2	15	3	Playa del Rey
Birch-Royer Oil Co.	28	2	15	1	Playa del Rey
Bishop Corp.	28	2	15	Venice 2	Playa del Rey
Black Gold Petroleum Co., Ltd.	21	2	15	1	Playa del Rey
Black Gold Petroleum Co., Ltd.	21	2	15	Francis J. Heney 2	Playa del Rey
Blue Ridge Oil Co., Ltd.	28	2	15	Blue Ridge 5	Playa del Rey
Blue Ridge Oil Co., Ltd.	28	2	15	Daly 15	Playa del Rey
Blue Ridge Oil Co., Ltd.	28	2	15	Hertel 14	Playa del Rey
Blue Ridge Oil Co., Ltd.	28	2	15	Stanley 3	Playa del Rey
Brooks-Rankin Oil and Gas Co., Ltd.	28	2	15	1	Playa del Rey
California Northern Corp.	28	2	15	3	Playa del Rey
Chanel Oil Co., Ltd.	28	2	15	1	Playa del Rey
Clark Oil & Royalties Corp., Ltd.	21	2	15	3	Playa del Rey
Clark Oil & Royalties Corp., Ltd.	28	2	15	2	Playa del Rey
Coloma Oil Corp., Ltd.	21	2	15	Coloma 2	Playa del Rey
Walter M. Crawford	21	2	15	2	Playa del Rey
Del Oro Oil Co.	28	2	15	Cain 1	Playa del Rey
Dennis & Palmer	21	2	15	1	Playa del Rey
Donley & Barteaux	28	2	15	Donley-Del Rey 1	Playa del Rey
Drexel Oil Co., Ltd.	21	2	15	1	Playa del Rey
Duncan Oil Corp., Ltd.	21	2	15	1	Playa del Rey
The Elmer Co., Ltd.	28	2	15	7	Playa del Rey
The Elmer Co., Ltd.	28	2	15	8	Playa del Rey
L. H. Freeman	28	2	15	2	Playa del Rey
George F. Getty, Inc.	28	2	15	V 6	Playa del Rey
George F. Getty, Inc.	28	2	15	V 7	Playa del Rey
Gibraltar Oil Corp., Ltd.	28	2	15	1	Playa del Rey
Goodfield Petroleum, Ltd.	28	2	15	Venice 3	Playa del Rey
H. L. J. Oil Co., Ltd.	28	2	15	2	Playa del Rey
Hartung-Hogan, Ltd.	28	2	15	Hartung-Hogan, Ltd. 1	Playa del Rey
Sam B. Herndon Oil Co., Ltd.	28	2	15	D. & G. Herndon 1	Playa del Rey
Inland Petroleum Co., Ltd.	28	2	15	1	Playa del Rey

OIL FIELD DEVELOPMENT OPERATIONS—Continued

Company	Sec.	Twp.	Range	Well No.	Field
LOS ANGELES COUNTY—Continued					
International Petroleum Corp., Ltd.	21	2	15	2	Playa del Rey
International Petroleum Corp., Ltd.	28	2	15	3	Playa del Rey
E. E. Jennings	28	2	15	1	Playa del Rey
A. T. Jergins Trust	28	2	15	Langley 1	Playa del Rey
A. T. Jergins Trust	28	2	15	Troxel 1	Playa del Rey
Thomas Kelly & Sons, Inc.	28	2	15	9	Playa del Rey
Thomas Kelly & Sons, Inc.	28	2	15	Gage 2	Playa del Rey
Thomas Kelly & Sons, Inc.	28	2	15	Kelly-Prentiss 3	Playa del Rey
Thomas Kelly & Sons, Inc.	28	2	15	P. E. 1	Playa del Rey
Knox, Powell, Stockton Co., Inc., Ltd.	21	2	15	W. G. Davis 4	Playa del Rey
Knox, Powell, Stockton Co., Inc., Ltd.	28	2	15	W. G. Davis 3	Playa del Rey
L. S. R. Petroleum Properties, Ltd.	21	2	15	1	Playa del Rey
La Canada, Ltd.	28	2	15	5	Playa del Rey
Lang-Wall	28	2	15	2	Playa del Rey
Langford Oil Co., Ltd.	28	2	15	1	Playa del Rey
Marcell Oil & Gas Corp., Ltd.	21	2	15	Black 4	Playa del Rey
Marcell Oil & Gas Corp., Ltd.	28	2	15	3	Playa del Rey
Metropolitan Oil Corp., Ltd.	28	2	15	2	Playa del Rey
Metropolitan Oil Corp., Ltd.	28	2	15	4	Playa del Rey
Mohawk Petroleum Co.	28	2	15	I 2	Playa del Rey
Mohawk Petroleum Co.	28	2	15	L 2	Playa del Rey
The Mutual Oil Co., Ltd.	28	2	15	2	Playa del Rey
Nelson Petroleum Co., Ltd.	28	2	15	3	Playa del Rey
The Ohio Oil Co.	28	2	15	Block I 2	Playa del Rey
The Ohio Oil Co.	28	2	15	Block L 1	Playa del Rey
The Ohio Oil Co.	28	2	15	Block L 2	Playa del Rey
The Ohio Oil Co.	28	2	15	Recreation Gun Club 6	Playa del Rey
The Ohio Oil Co.	28	2	15	Recreation Gun Club 7	Playa del Rey
The Ohio Oil Co.	28	2	15	Recreation Gun Club 8	Playa del Rey
The Ohio Oil Co.	28	2	15	Recreation Gun Club 9	Playa del Rey
Pacific Coast Properties, Ltd.	28	2	15	Lewis S. Stone-Hunter 2	Playa del Rey
Pacific Shore Oil Co., Ltd.	28	2	15	2	Playa del Rey
Pacific Shore Oil Co., Ltd.	28	2	15	3	Playa del Rey
Pacific Shore Oil Co., Ltd.	28	2	15	4	Playa del Rey
Pacific States Holding Co., Ltd.	28	2	15	1	Playa del Rey
Pan California Oil Corp.	28	2	15	10	Playa del Rey
Pan Gulf Petroleum Co., Ltd.	21	2	15	3	Playa del Rey
Pan Gulf Petroleum Co., Ltd.	28	2	15	4	Playa del Rey
Philco Petroleum Co., Ltd.	28	2	15	1	Playa del Rey
Protective Oil Co., Ltd.	21	2	15	1	Playa del Rey
Rich Petroleum Co., Ltd.	28	2	15	Swartz 1	Playa del Rey
Royal Petroleum Corp., Ltd.	28	2	15	1	Playa del Rey
Santa Catalina Oil Co.	28	2	15	1	Playa del Rey
Senator Oil Co., Ltd.	21	2	15	Senator 1	Playa del Rey
Don S. Shadle	28	2	15	Shadle 1	Playa del Rey
Speedway Oil Co., Ltd.	21	2	15	Bradley-King 1	Playa del Rey
Toy Rebhausen Co., Ltd.	28	2	15	2	Playa del Rey
Union Oil Co.	28	2	15	Del Rey 2	Playa del Rey
Union Oil Co.	28	2	15	Townsite 5	Playa del Rey
Union Oil Co.	28	2	15	Townsite 6	Playa del Rey
Union Oil Co.	28	2	15	Townsite 7	Playa del Rey
Van Wig Oil Co., Ltd.	28	2	15	1	Playa del Rey
Venice Consolidated Oil Co., Ltd.	21	2	15	1	Playa del Rey
Venice Consolidated Oil Co., Ltd.	21	2	15	2	Playa del Rey
Venice Consolidated Oil Co., Ltd.	28	2	15	3	Playa del Rey
Venice Oil Syndicate	28	2	15	5	Playa del Rey
Venice Oil Syndicate	28	2	15	6	Playa del Rey
Venice Oil Syndicate No. 7	28	2	15	7	Playa del Rey
Vicar Petroleum Corp.	28	2	15	1	Playa del Rey
West Bay Oil Co., Ltd.	28	2	15	1	Playa del Rey
West Coast Petroleum Combinations, Inc.	28	2	15	1	Playa del Rey

OIL FIELD DEVELOPMENT OPERATIONS—Continued

Company	Sec.	Twp.	Range	Well No.	Field
LOS ANGELES COUNTY—Continued					
Western Marine Oil Co., Ltd.	28	2	15	1	Playa del Rey
George Wolfe	28	2	15	4	Playa del Rey
George Wolfe	28	2	15	5	Playa del Rey
Wood Petroleum Corp., Ltd.	28	2	15	1	Playa del Rey
Continental Oil Co.	3	5	12	McGrath & Selover 25	Seal Beach
California Ventura Oil Co.	31	3	14	2	Torrance
California Ventura Oil Co.	6	4	14	3	Torrance
C. M. Sheeley	12	4	14	1	Torrance
George Wolfe	6	4	14	Hermosa 1	Torrance
Bardeen Petroleum Co., Ltd.	2	2	10	Puente 2	
Cudahy Community Oil Asso.	30	2	12	1	
Hines Petroleum Corp., Ltd.	9	2	15	Happy Days 1	
Lamona Oil Asso.	34	1	9	2	
Mack Oil Co., Ltd.	6	2	16	1	
McKeon Oil Co.	1	3	14	Western 1	
Rancho Oil Corp., Ltd.	30	1	11	Harmon 1	
Rucker & Croul	22	2	10	2	
San Val Oil Co., Ltd.	14	1	16	1	
Taylor Oil Co., Inc.	12	2	15	1	
The Vega Oil Co., Ltd.	14	2	10	1	
Wilmington Consolidated Oil Co., Ltd.	17	4	13	1	
C. L. Wood	10	3	14	1	
ORANGE COUNTY:					
T. F. Gesell	29	6	10	1	Newport
The Texas Co.	7	4	9	Olive Comm. 1	
SAN BERNARDINO COUNTY:					
Sancol Properties, Ltd.	18	1	4	1	
Western Gulf Oil Co.	12	3	8	Abacherli 1	
SAN DIEGO COUNTY:					
J. Russell Jones	Pueblo City	Lot of San	212, Diego	1	
SAN LUIS OBISPO COUNTY:					
Continental Oil Co.	26	25	11	Hellman 1	
Miracle Petroleum Corp., Ltd.	Lot 53	10	24	1	
C. Shockley	13	32	12	101	
SANTA BARBARA COUNTY:					
Barnsdall Oil Co.	14	4	29	Bishop-Evans 1	Elwood
Barnsdall Oil Co.	15	4	29	88-7	Elwood
Barnsdall Oil Co.	16	4	29	88-6	Elwood
Eagle Canyon Oil Co., Ltd.	16	4	29	Boone 208 1	Elwood
Caroline C. Spalding	16	4	29	Blue Goose 93-5	Elwood
Vaqueros Major Oil Co., Ltd.	6	7	33	3	Lompoc
Cuyama Valley Oil Corp., Ltd.	12	10	27	1	
Palisades Petroleum Corp.	28	4	27	2	
Palisades Petroleum Corp.	28	4	27	Meigs 2	
Petroleum Finance Corp.	34	4	25	202-1	
Scott-McIntosh Petroleum, Inc.	28	4	27	Caldwell 1	
W. H. Taylor	33	5	30	1	
SANTA CRUZ COUNTY:					
M. P. Shepherd	14	11	2	1	
Skookum Oil & Investment Corp., Inc.	19	11	2	1	
TULARE COUNTY:					
L. H. Larson & M. U. Stanford	11	23	27	2	
W. D. McCoy	35	21	27	1	
Roetnor Oil Co., Ltd.	34	22	27	1	
Terra Bella Drilling Co., Ltd.	23	22	27	1	

OIL FIELD DEVELOPMENT OPERATIONS—Continued

Company	Sec.	Twp.	Range	Well No.	Field
VENTURA COUNTY:					
Knudsen-Schmidt Co.	12	4	23	1	Ojai
Neil C. Needham	7	3	24	Needham 2	Rincon
Merchants Petroleum Co.	1	4	20	5	Sespe
Associated Oil Co.	23	3	23	Lloyd 104	Ventura
Associated Oil Co.	23	3	23	McGonigle 10	Ventura
Associated Oil Co.	23	3	23	V. L. & W. 2	Ventura
Associated Oil Co.	26	3	23	Lloyd 87	Ventura
Shell Oil Co.	29	3	23	Taylor 65	Ventura
Shell Oil Co.	29	3	23	Taylor 66	Ventura
Shell Oil Co.	29	3	23	Taylor 67	Ventura

SPECIAL ARTICLES

Detailed technical reports on special subjects, the result of research work on extended field investigations, will continue to be issued as separate bulletins by the Division, as has been the custom in the past.

Shorter and less elaborate technical papers and articles by members of the staff and others are published in each number of 'Mining in California.'

These special articles cover a wide range of subjects both of historical and current interest; descriptions of new processes, or metallurgical and industrial plants, new mineral occurrences, and interesting geological formations, as well as articles intended to supply practical and timely information on the problems of the prospector and miner, such as the text of the new laws and official regulations and notices affecting the mineral industry.

BERYLLIUM AND BERYL[1]

By Alice V. Petar[2]

INTRODUCTION

Beryllium, or glucinum, is often listed as a rare element, though it probably is more abundant in the earth's crust than many of the minor metals that are ordinarily considered rather common. According to J. H. L. Vogt,[3] between 0.01 and 0.001 per cent of the entire lithosphere is beryllium. It is not a new metal, for it has been known for more than a hundred years, but even yet it has not been put to work commercially except to an extremely limited extent. Since beryllium is very light and exceptionally hard and strong, many believe that it is destined to share with magnesium and aluminum in the fast-growing demands for light metals to be used in the construction of aircraft. Active interest has been aroused in the possibilities of beryllium, and the Bureau of Mines has received numerous inquiries with regard to the metal and more especially with regard to sources of beryl.

The mineral beryl, which seldom contains more than about 5 per cent of the element, is the only recognized ore of beryllium. It is a common accessory in pegmatite veins and is also found in clay slate and mica schist, but hitherto only the gem varieties, including emerald and aquamarine, have been actively sought. In several localities, however, ordinary beryl is produced as a by-product in mining mica and feldspar, and often beryl has accumulated on the dumps because no buyer could be found. Only within the last two or three years has there been an active demand for the mineral, even in ton lots, and as yet requests for carload shipments are extremely rare. Considerable interest has been awakened, nevertheless, in the possibility of opening deposits that will yield beryl in substantial quantity.

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[1] Reprinted from U. S. Bureau of Mines Information Circular 6190.
[2] Rare metals and nonmetals division, U. S. Bureau of Mines.
[3] Vogt, J. H. L., Problems in the Geology of Ore Deposits. Trans. Am. Inst. Min. and Met. Eng., vol. 31, 1901, p. 128.

Changes are taking place rapidly in activities concerning beryllium. The present circular is presented with no claims that it records all of the latest developments. It represents merely a summary of information which has accumulated in the files of the Bureau of Mines and which, it is hoped, will prove useful to those interested in the production or utilization of this newest of the light metals.

Beryllium

DESCRIPTION AND PROPERTIES

The metal beryllium, or glucinum, has aroused the interest of many investigators, who have worked out various processes of extracting it from its ores. Beryllium is very light, having about the same specific gravity as magnesium, and is almost as hard as quartz. It will scratch glass and it takes a high polish. Early investigators claimed that beryllium was malleable and could be easily forged and cold-rolled into sheets, but later studies do not support these claims. While it is possible that absolutely pure beryllium, if obtained, might have the qualities formerly attributed to it, investigations conducted at the Bureau of Standards[4] with metal of 98.7 per cent purity indicated the contrary. This product was described as ''coarsely crystalline, reminding one of antimony or bismuth, * * * hard and brittle, and apparently incapable of being wrought cold.'' It is further stated that more recently metal of more than 99.5 per cent purity has been produced, some lots of which are semimalleable cold and can be rolled hot into a thin sheet. The melting point of beryllium has been determined as 1285° C., or a little above that of manganese.

USES

Considerable research has been carried on in this country and abroad toward the development of uses for beryllium, but the use of the metal is still in the experimental stage and its commercial applications are definitely limited until such time as the cost of extraction, now almost prohibitively high, can be reduced. From time to time there have been items in the press describing it as the new and logical light metal for aviation use, and the Materials Subcommittee of the National Advisory Committee for Aeronautics is planning to arrange for tests of beryllium for use in airplane construction. Nevertheless, to date, this use has not materialized, and the Siemens-Halske Company in Germany, which has been particularly diligent in its studies of the properties and possible uses of the metal, has concentrated its efforts chiefly upon alloys containing small quantities of beryllium with heavy metals, such as iron, copper, and nickel. It is claimed[5] that—

> * * * Beryllium hardens iron to a great extent; by an addition of only 2 per cent the hardness is increased from about 100 to 300. By means of heat-treatment this hardness can be increased to 500 to 600, so that the iron is as good as the "C" steels. Beryllium-iron alloys with more than a 4 per cent beryllium content can not even be rolled, either cold or hot. But such alloys can be improved so that hardnesses are obtained which are only very slightly below that of hardened steel.
>
> The alloys of beryllium with copper and nickel merit special attention. * * * The resistance properties of such alloys with 2 to 3 per cent of beryllium in an untreated condition are about equal to those of a high-grade annealed bronze. However, by means of a suitable treatment, one obtains strengths which are far beyond those of a doublespring, hard, rolled or drawn bronze, while the expansion values are about equal. A special superiority of the beryllium-copper and beryllium-nickel alloys over bronze is that they can

[4] U. S. Bureau of Standards, Light Metals and Alloys—Aluminum, Magnesium (with bibliography). Circular 346, 1927, pp. 314-315.

[5] Illig, Kurt, Production and Utilization of Beryllium Metal. Zschr. Angew. Chem. vol. 40, 1927, pp. 1160-1163. Translation, Foote-Prints, vol. 1, No. 4, 1928, pp. 30-38.

be worked as desired while in the untreated condition, to be hardened by proper treatment after completion, while bronze already receives its great hardness and strength during the cold shaping, and no further shaping is possible while in this condition. As compared to the carbon-steels, these alloys furthermore show a great resistance to corrosion. They will, therefore, find application in technology wherever, in addition to this almost universal requirement, the highest demands in respect to grinding, stamping, spring making, etc., come under consideration.

In Great Britain, beryllium has been studied at the National Physical Laboratory under a committee of the Department of Scientific and Industrial Research. Efforts have been made to prepare the metal in a purer, and if possible, more ductile form. Small quantities of beryllium metal have become available in the course of the investigation, and an attempt has been made to study the alloys of iron and beryllium.[6]

In the United States the metal has been produced on a semi-commercial scale by the Beryllium Corporation of America at Cleveland. While this company has devoted some attention to the heavy alloys, chiefly those of beryllium with gold and silver, its chief interest has been with the beryllium-aluminum alloys. Menahem Merlub-Sobel, formerly chemical engineer of the Beryllium Corporation of America, states[7] that the addition of beryllium to aluminum increases its strength and resistance to corrosion, and that an alloy containing 70 per cent beryllium and 30 per cent aluminum "exhibits materially greater resistance to salt water and air corrosion than any other of the light alloys."

Beryllium has been used in this country and abroad in X-ray apparatus. Another use which may grow considerably is for electrodes in connection with neon signs.

Experiments have been conducted at the University of Pittsburgh[8] on over eighty different glasses in which beryllium oxide replaced calcium oxide or magnesium oxide. It was found that beryllium glasses are somewhat more refractory than magnesium or calcium glasses and that beryllium glass is much harder than calcium or magnesium glass. Results so far obtained indicate that beryllium glasses warrant further study.

HISTORY

In 1797 Haüy, a mineralogist, found that the minerals beryl and emerald have the same physical structure, hardness, and specific gravity, and at his suggestion, L. N. Vauquelin proved that these minerals are identical chemically. In making the analysis he also discovered that they contain an oxide which at first he took to be alumina, but upon closer study found that it had several distinct properties. It was precipitated from its potassium hydroxide solution by boiling; its salts had a sweet taste; its hydroxide was soluble in dilute ammonium carbonate and formed an alum.

In first describing the new element, Vauquelin did not give it a name, but referred to it as "the earth of beryl." The editors of the Annales de Chimie suggested the name of "glucine," meaning sweet, because of the taste of its salts, and in a later article Vauquelin adopted their sug-

[6] Chemical Age, The Search for New Alloys. Vol. 18, April 7, 1928, p. 316.

[7] Sobel, Menahem Merlub, Beryllium. Metals and Alloys, vol. 1, Aug., 1929, pp. 69-70.

[8] Lai, Chi Fang, and Silverman, Alex, Beryllium Glass. Jour. Am. Ceram. Soc., vol. 11, 1928, pp. 535-41.

gestion. H. F. Link took exception to the use of this name because of its resemblance to "glycine," which was already in use, and M. H. Klaproth, calling attention to the fact that the salts of yttrium earths were also sweet, proposed "beryllerde" as a preferable name. For a time the element was referred to as "beryllerde" in Germany and "glucine" in France.

In 1828 F. Wöhler isolated the metal and called it beryllium, and subsequently the names glucinum and beryllium have been used indiscriminately. Both names have their advocates.

The early history of beryllium has been described by Parsons[9] as follows (original references omitted):

> Following the discovery of the element, Vauquelin studied and announced the properties of some of its chief compounds. In 1928 the metal itself was produced in a very impure form by both Wöhler and Bussy. Awdejew added materially to the literature of the subject and made the first determinations of the atomic weight that have any claim to accuracy. Weeren and Debray also carried on extensive investigations of the metal, its atomic weight and chief compounds. Joy undertook an extended research on the preparation of its compounds from beryl and published a fairly complete bibliography of the subject to his day. Atterberg and Nilson and Pettersson, in the years between 1873 and 1885, made large additions to the chemistry of beryllium, and during these years a long, earnest, and interesting discussion, which had begun as early as Awdejew's time, was carried on by Nilson and Pettersson, Humpidge, Reynolds, Hartley, Lothar Meyer, Brauner, and others regarding the valency of beryllium and its place in the periodic system. The discussion has continued up to the present day, but was in reality settled when Nilson and Pettersson determined the vapor density of the chloride, and Humpidge showed that at high temperatures the specific heat of beryllium approached very closely to normal. Krüss and Moraht made a redetermination of the atomic weight in 1890, and between the years 1895 and 1899 Lebeau published an important series of articles which are summed up by him in one of the very best articles on beryllium and its compounds. Urbain and Lacombe discovered the remarkable basic salts of the acetic acid series and Parsons redetermined the atomic weight by new methods and studied many compounds, especially the so-called basic salts of some of the earlier writers. Numerous other investigators * * * have also contributed to the chemistry of beryllium.

In 1913 Fichter and his pupils prepared beryllium in sufficient quantity to study its properties, employing the methor of M. Lebeau, and obtained a 98 per cent pure metal.

In 1916 Oesterheld[10] published an important experiment. He studied more particularly the equilibrium diagrams of the alloys beryllium-iron, beryllium-aluminum, beryllium-copper, and beryllium-silver.

In 1921 Stock and Goldschmidt, in Germany, with the cooperation of Priess and Praetorius, obtained metallic beryllium for the first time in the form of large buttons, directly from a fused electrolyte. Their investigations are described in some detail by Illig[11], who says, in part:

> * * * Before starting their experiments, Stock and Goldschmidt made an effort to find a method by which all of the limiting conditions would be eliminated. They felt that the electrolytic separation of beryllium (melting at 1285° C.) from a fused salt mixture could only be possible if a salt be used, which at this temperature either did not evaporate at all, or at least did so only slightly. On the other hand, to avoid an unusually high potential drop between the electrodes, the salt must also possess at this temperature a very

[9] Parsons, C. L., The Chemistry and Literature of Beryllium. Chem. Publishing Co., Easton, Pa., 1908, p. 2.
[10] Oesterheld, Ueber den Schmelzpunkt und die Schmelzwaerme des Beryllium. Ztschr. anorg. Chem. vol. 97, 1916, p. 1.
[11] Illig, Kurt, The Production and Uses of Beryllium. Trans. Am. Electrochem. Soc., vol. 54, 1928, pp. 53-64.

low viscosity; and furthermore, the anions must be easily separated or removed from the electrolyte. It is only in this manner that the separated metal might be prevented from remaining in, or being redistributed in, the surrounding fused salt mass.

Investigations have shown that these conditions are fulfilled in general by the double fluorides of beryllium with sodium and barium. The barium-beryllium fluoride has an appreciable viscosity around 1300° C., but also has the advantage of being only slightly volatile at this temperature range; it has an appreciable dissociation within this range. The sodium beryllium fluoride is strongly dissociated even at relatively low temperatures. This, therefore, offers a means of obtaining an electrolyte possessing a good conductivity. It has only one disadvantage, namely, that at very high temperatures the separated beryllium metal may be volatilized in appreciable quantities.

If the electrolysis is started with the sodium-beryllium fluoride, and with rising temperatures, some barium-beryllium fluoride is added in increasing amounts, there is obtained a useful mixture of the double salts for every temperature interval. When the final metal separating temperature of 1300–1350° C. is reached, it is not difficult to continue the electrolysis for many hours, provided suitable additions of both double salts are made from time to time.

Stock and Goldschmidt protected this general method of procedure by letters patent in all large countries. They realized, however, that much additional work was necessary before all of the details for the continuous production of large quantities of beryllium would be established.

In order to study the problems on the broadest basis, the foremost German manufacturers organized a "Beryllium Research Institute" in 1923, under the chairmanship of Siemens & Halske, A. G. of Berlin. It was the aim of this Institute to make a systematic study of the fundamental Stock-Goldschmidt method in all of its details and to determine whether or not it was possible to produce beryllium metal in commercial quantities from fused electrolytes. * * * In 1926 the Institute felt convinced that in the Stock-Goldschmidt method there was a means by which a commercial production of beryllium metal might be expected. At the same time the commercial applications of this metal were studied.

The Stock-Goldschmidt process was developed and improved by the Siemens & Halske, A. G., and it is reported that an experimental plant capable of producing about a ton of beryllium metal yearly is nearing completion.

PRICES

Beryllium is quoted in the United States at $200 per pound, and shipments are made chiefly from small stocks manufactured in 1927 or earlier. As in all metallurgical operations, the production of the metal on a laboratory or semicommercial scale is much more costly than it would be in large lots. Menahem Merlub-Sobel[12] estimates that the metal could be manufactured "at less than $5 per pound if, and when, the market absorbed 100 tons or more per annum; this without crediting the metal with certain by-products obtained in the course of its manufacture."

Kurt Illig[13] has predicted that when the production of the Siemens-Halske Co. reaches one ton of beryllium per year, the price will be $35 to $40 per pound ($75 to $90 per kilogram), and that should the sale of the metal increase to 100 metric tons a year it may be possible to cut the price by two-thirds or to $12 or $13 a pound.

BERYLLIUM MINERALS

Beryllium is present in a great number of granitic rocks and to a minor extent in clay slate and mica schist, in the form of aluminates,

[12] Work cited, p. 79.

[13] Illig, Kurt. The Production and Uses of Beryllium. Trans. Am. Electrochem. Soc., vol. 54, 1928, pp. 53-64.

silicates, phosphates, borates, etc. Beryl, which appears to be by far the leading, if not the only ore of the metal, is a common accessory of pegmatite veins. It alters to mica and kaolin, and the beryllium oxide thereby released may reappear as a constituent of secondary minerals, notably bertrandite, herderite, and beryllonite.

Due to the lack of a market for any but the gem varieties of beryl there has been no incentive until recently to develop deposits. Until a year or two ago the total output in the United States probably did not exceed 10 or 15 tons a year and even now (1929) demand is limited to occasional shipments in less than carload lots.

Beryl

Beryl is a complex silicate of aluminum and beryllium. When pure it has the formula $3BeO.Al_2O_3.6SiO_2$ and contains 14 per cent beryllium oxide, but often the beryllium is replaced by other oxides, such as calcium, iron, chromium, potassium, sodium, or cesium. In color, beryl varies from white or colorless to green, blue, yellow (amber), and even red, but usually it is some shade of green. Clear transparent crystals are cut as gems. The deep green variety, the color of which is attributed to the presence of a little chromium, is the emerald [14] which is worth more than the diamond. Aquamarine, a sky-blue or greenish-blue variety, is also a precious stone. Beryl is about as heavy as quartz, sometimes a little heavier (specific gravity, 2.63 to 2.8), but its outstanding characteristic is its hardness (7.5 to 8). It is harder than quartz or tourmaline and practically as hard as topaz, from which it differs in that it has no distinct cleavage. It crystallizes in hexagonal prisms ranging in size from mere thread-like pieces to huge crystals many feet in length and weighing several tons. Occasionally it occurs in large columnar or granular masses.

USES OF BERYL

In addition to its potential value as a source of beryllium metal, ordinary beryl may have other uses, notably as a substitute for feldspar in the manufacture of porcelain. This use has been described by W. M. Myers[15] as follows:

> Investigations carried on by the Bureau of Standards (Bleininger, A. V., and Riddle, F. H., Special Spark-plug porcelains. Jour. Am. Ceram. Soc., vol. 2, July, 1919) have shown that when beryl is substituted for feldspar in the manufacture of porcelain in amounts varying from 25 to 45 per cent of the total mixtures, the other components being silica and clays, a product is obtained which displays a very high electrical resistance and low thermal expansion. This porcelain is therefore considered a very promising material for electrical uses. Due to the scarcity of beryl there has been no commercial production of this type of porcelain.

OCCURRENCES OF BERYL

United States

Good emeralds have been found in Massachusetts and in North Carolina (Alexander County, especially from Stony Point). Aquamarines

[14] The so-called oriental emerald is a variety of corundum, an aluminum oxide.
[15] Myers, W. M., New Uses of Nonmetallic Minerals. Rep. of Investigations, Serial 2587, Bureau of Mines, 1924, p. 5.

and other gem specimens have been obtained at Paris and Stoneham, Me.; Mount Antero, Colo., and several places in North Carolina. The best emeralds, however, are mostly imported. The world supply comes from Colombia, British India, Brazil, Sibera, Australia and (recently) South Africa.

Occurrences of beryl, as described by the United States Geological Survey,[16] may be summarized as follows:

Alabama.

Coosa County: Crystals suitable for gems have been found near Rockford and Hissop.

California.

Riverside County: Fine yellow and green beryls occur at Coahuila, and rose crystals near Hemet.
San Diego County: Aquamarine variety is mined intermittently at Pala, Rincon, Mesa Grande, and Ramona; yellow, green, and blue crystals occur in the Palomar Mountains nine miles southeast of Pala.
Tuolumne County: Jamestown (reported).

Colorado.

Boulder County: Near Glendale.
Chaffee County: Occurs near top of Mount Antero; color varies from light blue to deep aquamarine green; fine gems, worked intermittently.
Clear Creek County: Georgetown.
Fremont County: East Gulch, six and one-half miles north of Texas Creek; mined, few gems cut.
Jefferson County: Near Creswell.
Park County: Buffalo Mountain.

Connecticut.

Fairfield County: At Branchville.
Litchfield County: Gem golden beryl and aquamarine were mined with mica and feldspar six miles north of New Milford.
Middlesex County: Abundant in the pegmatite at several quarries in Middletown, Portland, Chatham, and Haddam; gem aquamarine found in some of these, especially in Portland and Haddam.
New Haven County: Found in Southford quarry.

Georgia.

Rabun County: Beck beryl mine seven miles east of Clayton. Large flawed crystals in pegmatite contain clear portions suitable for cutting.

Maine.

AQUAMARINE:

Kennebec County: At Winslow, with mica and flourite in cassiterite vein.
Oxford County: French Mountain, town of Albany; Bunton mine, town of Newry; Mount Mica, town of Paris; associated with corundum, town of Greenwood: Sugar Hill and Harnadon Hill, town of Stoneham.
Sagadahoc County: At Topsham feldspar quarries.

CESIUM BERYL:

Androscoggin County: Berry quarry, town of Poland.
Oxford County: Town of Hebron; on Dudley farm, town of Buckfield.

GOLDEN BERYL:

Oxford County: Edgecomb Mountain, town of Stoneham, and Speckled Mountain, town of Peru.
Opaque varieties common in pegmatites, notably:
Androscoggin County: Apatite Hill, town of Auburn.
Hancock County: In cassiteriate-bearing granite at Catharine Hill.
Oxford County: Noyes mine, town of Greenwood.

[16] Schrader, F. C., Stone, R. W., and Sanford, Samuel, Useful Minerals of the United States. U. S. Geol. Surv. Bull. 624, 1916, 412 pp.

Massachusetts.

Worcester County: At Royalston, best locality in state, blue and yellow gem quality, worked intermittently.
Franklin County: At Northfield.
Hampden County: Blandford.
Hampshire County: Chesterfield, Goshen and Norwich.

EMERALD:

Hampshire County: Reported specimens found at Chesterfield and Goshen.

New Hampshire.

Common in pegmatite ledges of Cheshire, Grafton, Merrimack and Sullivan counties.
Cheshire County: Large crystals found in Nim's mica mine, town of Sullivan; both gem aquamarine and golden beryl have been mined at Island mica mine in town of Alstead; gem and specimen beryl found in town of Roxbury.
Grafton County: Large crystals found at Standard mica mine near Orange; at De Mott mine, Kilton mine, and Alger Hill mine near Grafton Center; Horse Hill near Grafton; Wilcher and Pillsbury mine in town of Wentworth; and at New Haven mica mine, town of Alexandria; gem aquamarine and golden beryl have been mined at Reynolds mine on Sanders Hill and at Playter mine in Springfield mountains, south of Grafton.
Merrimack County: Plentiful on Stuart Hill, two miles west of Danbury.
Sullivan County: Crystals measuring one inch to two feet in diameter found at Beryl Mountain near South Acworth.

New Mexico.

Santa Fe County: Near Santa Fe, a few crystals of fine quality found in the gravels, not worked.

North Carolina.

Alexander County: Mined at Hiddenite-Emerald mine.
Burke County: Near Burkmont in South Mountains.
In mica mines in Alexander, Iredell, Mitchell and Yancey counties.

AQUAMARINE:

Alexander County: Mined at Hiddenite and Ellis mines, near Hiddenite.
Burke County: Has been found in South Mountain.
Jackson County: Mines several miles south of Cashiers.
Macon County: Mined at head of Tessentee Creek.
Mitchell County: Mined at Wiseman and other mica mines.
Yancey County: In Ray and other mica mines.

Pennsylvania.

Chester County: Union township, near Northrop and Unionville, has yielded hundreds of pounds of crystals.
Delaware County: Deshong's quarry at Leiperville; the Shaw-Ezra quarry at Chester; Avondale quarry near Media; many localities in Concord, Marble, Middletown and Upper Province townships; Linwood, occasionally found.
Philadelphia County: Fairmount Park, Germantown, Logan, Mount Airy and Shawmont have all produced gem specimens.

South Carolina.

Anderson County: A few crystals sufficiently clear to be cut for gems have been found at McConnel Place, three miles north of Anderson. Occurs at numerous points along the Anderson-Spartanburg zone. Cut for gems.

South Dakota.

Custer County: Large crystals and masses occur in pegmatites with tin and mica.
Pennington County: In pegmatites near Keystone.

Utah.

Tooele County: About thirty-five miles southwest of Simpson Springs, Ibapah Mountain.

Virginia.

Amelia County: Amelia mica mines.
Henry County: In pegmatite near Axton.
Rockbridge County: With cassiterite in Irish Creek area.

In the spring of 1928, in order to obtain an approximate idea as to the beryl resources and production of the United States, the Bureau of Mines addressed questionnaires to the mica and feldspar producers of the country. The replies indicated that the only production of any consequence was from the Black Hills of South Dakota, New York, Maine and New Hampshire, and at that time several of the producers had stocks on hand for which they were desirous of finding a market.

Maine.

Occurrences in Maine are described in some detail by Bastin,[17] who summarizes the beryl resources of the state, as follows:

> * * * Opaque crystals are quite common in most of the coarser pegmatite deposits of Maine, where they occur as more or less regular prisms embedded in the solid pegmatite. Some of these reach remarkable dimensions: one found in the Maine Feldspar Company's quarry at Mount Apatite in Auburn was described as having a diameter equal to that of a hogshead. One from the Noyes gem mine in Greenwood, Oxford County, was so large that a man could barely reach around it with his arms. * * *
>
> Emeralds are of rare occurrence in the pegmatite deposits of Maine. One crystal of light grass-green color embedded in quartz was observed by the writer at the Dunton gem quarry in Newry, Oxford County. It was a prism half an inch across and 1½ inches long but was so badly fractured as to be valueless for gems. * * *
>
> The light blue to sky-blue and light green transparent varieties of beryl known as aquamarine are more abundant than any of the other gem varieties of beryl found in Maine, and specimens of remarkable size and beauty have been obtained. * * * Most of the gem material has come from Oxford County. Some has been obtained from what is known as the Emmons mine in the southwestern part of Greenwood, from French Mountain in Albany, Sugar Hill in Stoneham, and Lovell, Bethel and other towns. A fine sea green aquamarine weighing about seven carats was found near Sumner. Recently some good gems have been obtained on the Dudley farm in Buckfield. * * *
>
> Beautiful transparent golden-yellow beryls have been obtained in the pegmatites at various points in Oxford County, at Edgecomb Mountain in Stoneham, in Albany, and recently good gem material of a straw yellow has been obtained from the west side of Speckled Mountain in Peru. They are mined sporadically by gem collectors, mostly from small prospects. * * *
>
> A colorless to bluish-white or pinkish-white variety of beryl containing a small percentage (1.66 per cent to 3.6 per cent) of oxide of cesium was first discovered in Hebron, Oxford County, but has since been found to occur at a number of other pegmatite localities in the western part of the State, notably at Mount Mica in Paris, at the Dudley farm in Buckfield, Oxford County, and

There is also an interesting occurrence of beryl at the Bumpus Quarry, Bethel, Me., in which large crystals have been exposed.

New York.

Beryl, associated with feldspar, occurs at Bedford, Westchester County. The deposit is one of the principal sources of beryl in the East.

South Dakota.

The largest potential source of beryl is apparently in the Black Hills of South Dakota. The deposits in that region are described as follows:[18]

> Beryl occurs in greater or less amounts in nearly all of the pegmatite bodies of the southern Black Hills, and is also found in some of those of the Nigger

[17] Bastin, Edson S., Geology of the Pegmatites and Associated Rocks of Maine. U. S. Geol. Surv. Bull. 445, 1911, 152 pp.
[18] Connolly, Joseph P., and O'Harra, Cleophas C., The Mineral Wealth of the Black Hills. South Dakota School of Mines Bull. 16, 1929, pp. 254-5.

> Hill area in the northern Hills. Excellent crystals and crystal groups have been found in the Crown mica mine near Custer. It also occurs in the White Spar and New York mines, although in the latter it is somewhat impure, having much included quartz, feldspar, and tourmaline. Beryl occurs in considerable abundance in the pegmatites near Keystone. All four of the larger bodies show it, the Etta, Hugo, Peerless, and Ingersoll. At the Ingersoll may be seen at the present time what is probably the largest beryl crystal ever uncovered. A section across the prism is exposed here which is 46 inches in diameter. The length of the crystal is not known, as it has never been fully exposed. The Beryl Mica lode at Pringle, operated by the Dakota Feldspar Company, contains much beryl which gives promise of considerable commercial importance. * * * The value of the entire production from the Hills to date is probably less than $2,000.

High freight rates have proved a handicap in marketing the South Dakota material. On full carloads a rate of $17 a ton can be obtained in New York, but on less than carload lots—even shipments of 10 tons or more—a rate of $50 a ton has been charged.

Foreign Countries

Africa.

Two companies are reported to be actively interested in the production of beryl. The Beryl Mining Co. is working the Somerset mine in the Leydsdorp district, eastern Transvaal, and Beryllium, Ltd., has recently been organized for the purpose of working claims in Namaqualand. According to W. E. Bleloch, chairman of the Beryl Mining Co.,[19] the mine has been "steadily producing from 300 to 350 pounds of crystals per week from a total gross tonnage mined of approximately 300 tons." The material mined has apparently been marketed entirely as gem material, although Mr. Bleloch stated that the board was making inquiry with regard to the market value of beryllium metal.

The recently discovered deposits in Namaqualand have attracted considerable attention in the technical press, and it is stated[20] that preliminary excavating has resulted in the recovery of about 15 tons of beryl, averaging over 15 per cent BeO.

Brazil.

Crystals of beryl varying from 20 centimeters to two meters in circumference occur in the pegmatites of Minas Geraes and Bahia. Some of the mineral is in the form of aquarmarine, and one very large specimen weighing 110.5 kilograms was found in Marambaia.[21]

Canada.

Beryl deposits in Canada are located in Renfrew County, Ontario, about 150 miles northeast of Toronto, near the village of Quadville; and in the Abitibi region of the western part of the Province of Quebec, 20 miles southwest of Amos on the Canadian National Railway.[22] No definite information is at hand concerning the extent of these deposits, but the article referred to indicates that the deposit in Renfrew County gives promise of a large tonnage of high-grade beryl.

Colombia.

The emerald deposits, 75 kilometers from Muzo, are well known and have long been a source of gem stones.

India.

Beryl crystals are found in the mica mines in Nellore, varying in size from tiny crystals less than half a centimeter to those measuring a foot in diameter. V. S. Swaminathan[23] estimates that from three to five tons of beryl per year would be available. Beryl also occurs in the mica mines in Behar.

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[19] South African Mining and Engineering Journal, The Position and Prospects of Beryl Minings. Vol. 40, April 27, 1929, pp. 224.

[20] South African Mining and Engineering Journal, Remarkable Beryl Discovery. Vol. 40, June 22, 1929, pp. 477-80.

[21] Moraes, L. J. de, Nota sobre algunas jazidas de beryllo e mica do valle do Rio Doce, Estado de Minas Geraes. Ministerio da Agricultura, Industria e Commercio, Servico Geologico e Mineralogico do Brasil, Boletin No. 18, 1926, pp. 23-32.

[22] Bulletin of the Imperial Institute of Great Britain, Beryl in Canada. Vol. 24, No. 3, 1926, pp. 569-70.

[23] Swaminathan, V. S., The Mode of Occurrence and Chemical Composition of Beryl From Nellore, With a Note on Its Industrial and Chemical Applications. Trans., Min. Geol. Inst. India, vol. 22, pt. 3, Oct., 1928, pp. 258-267.

New South Wales.

Beryl occurs associated with tinstone at Elsnore, Mole Tableland; with feldspar, quartz, and mica at Ophir, Wellington Co.; at Shoalhaven River, east of Bungonia, and in alluvial deposits at Emmaville, Kangaroo Flat, Tungha Copes Creek, and Scrubby Gully.[24]

Siberia.

Transparent beryls occur near Ekaterinburg and Miask, and in the mountains of Adun-Chalon, in Eastern Siberia; some of the crystals exceed a foot in length. It is understood that the Soviet Government has for some time been carrying on active prospecting in various districts in the Urals, and Schlenzig[25] believes that the Siberian mining of beryl will be the decisive factor in forming the price of beryllium metals.

United Kingdom.

Beryl has been found in the Mourne Mountains of County Down; at Killiney, near Dublin; Rubislaw near Aberdeen; and at St. Michael's Mount, Cornwall.[26]

Minor Minerals

In addition to beryl, a number of other minerals are known which contain appreciable quantities of beryllium, though the minerals themselves do not occur in quantities sufficient to make them of economic interest as sources of beryllium. Negru[27] has summarized these minor minerals of beryllium as follows:

Bertrandite. A beryllium silicate of the composition $4BeO.2SiO_2.H_2O$ (50.3 per cent SiO_2, 42.1 per cent BeO, 7.6 per cent H_2O). It is found in Bohemia, France, and in the United States (Colorado, Maine, Virginia).

Colorado: Mount Antero, Chaffee County.
Maine: Stoneham, Oxford County.
Virginia: Amelia Court House, Amelia County.

Beryllonite. A sodium-beryllium phosphate of the composition $Na_3PO_4Be_3P_2O_8$ (55.9 per cent P_2O_5, 19.7 per cent BeO, 24.4 per cent Na_2O). It is found in the United States at Stoneham, Oxford County, Maine.

Chrysoberyl. A beryllium-aluminum oxide of the composition $BeO.\ Al_2O_3$ (80.2 per cent Al_2O_3, 19.8 per cent BeO). It is found in Brazil, Ceylon, Ireland, Moravia, Siberia, and the United States (Colorado, Connecticut, Maine, New Hampshire, and New York).

Colorado: Six miles west of Sedalia, Fremont County.
Connecticut: Haddam, Middlesex County.
Maine: Newry and Stoneham, Oxford County.
New Hampshire: New Orange Summit, Grafton County.
New York: Greenfield, Saratoga County.

Danalite. A complex mineral of the composition $(Be, Fe, Zn, Mn)_7\ Si_3O_{12}S$ with about 14 per cent BeO. It is found in the United States (Colorado, Massachusetts, New Hampshire).

Colorado: West Cheyenne Canyon, El Paso County.
Massachusetts: Essex County: Rockport, Cape Ann, Gloucester.
New Hampshire: Bartlett.

Gadolinite. A complex silicate of beryllium, iron and yttrium, of the composition $2BeO.FeO.2Y_2O_3.2SiO_2$ (23.9 per cent SiO_2, 51.8 per cent Y_2O_3, 14.3 per cent FeO, 10 per cent BeO). It is found in Greenland, Ireland, Norway, Silesia, Sweden, and the United States (Arizona, Colorado, Texas).

Arizona: Mohave County, in cliffs, 30 miles south of Hackberry, and near Kingman, about six miles west of Chin Lee Valley and two to four miles south of the Utah line.
Colorado: Douglas County, Devil's Head Mountain; Washington County, Akron,
Texas: Burnett County; Llano County: Baringer Hill. (Here are found crystals of gadolinite weighing up to 60 pounds.)

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[24] Bulletin of the Imperial Institute of Great Britain, The Source and Industrial Uses of Beryllium Compounds. Vol. 12, 1914, pp. 613-615.
[25] Schlenzig, J., Beryllium: Occurrence and Production Costs. Metal Industry (London), vol. 35, Aug. 2, 1929, pp. 107-8.
[26] Bulletin of the Imperial Institute of Great Britain, The Source and Industrial Uses of Beryllium Compounds. Vol. 12, 1914, pp. 613-615.
[27] Negru, J. S., Glucinum. Chem. and Met. Eng., vol. 21, 1919, pp. 353-359.

Helvite. A complex silicate of the composition $(Mn,Fe)S.3(Be.Mn,Fe)_2\ SiO_4$, with about 13.5 per cent BeO. It is found in Finland, Hungary, Norway, Saxony, and the United States (near Amelia Court House, Amelia County, Virginia.

Herderite. A fluophosphate of calcium and beryllium of the composition (CaF) BePO (43.8 per cent P_2O_3, 15.4 per cent BeO, 34.6 per cent CaO, 5.9 per cent F). It is found in Saxony and the United States (Maine: Hebron and Stoneham, Oxford County, and Auburn, Androscoggin County).

Phenacite. A beryllium orthosilicate of the composition $2BeO.SiO_2$ (54.45 per cent SiO_2, 45.55 per cent BeO). It is found in the Urals (near Ekaterinburg), France, Mexico (near Durango), Switzerland, and the United States (Colorado, Maine, Virginia).

Colorado: Chaffee County, Mount Antero and Devil's Head; El Paso County, Crystal Park, two miles southwest of Manitou, Teller County, Topaz, Butte, near Florissant, and at Cripple Creek in the Gold King Mine.
Maine: Near Stoneham, Oxford County.
Virginia: Amelia Court House, Amelia County.

Euclase. A beryllium-aluminum silicate of the composition $2BeO.2SiO_2.Al_2O_3H_2O$ (41.3 per cent SiO_2, 35.2 per cent Al_2O_3, 17.3 per cent BeO, 6.2 per cent H_2O). It is found in Brazil (Province of Minas Geraes), Ural (Orenburg District) and in the Austrian Alps.

Eudidymite. A beryllium-sodium silicate of the composition $H_2O.\ Na_2O.2BeO.6SiO_2$ (73.4 per cent SiO_2, 10.2 per cent BeO, 12.7 per cent Na_2O, 3.7 per cent H_2O). It is found in southern Norway, near Langesund fiord.

Hambergite. A beryllium borate of the composition $4BeO.B_2O_3H_2O$ (53.25 per cent BeO, 36.72 per cent B_2O_3, 10.03 per cent H_2O). It is found in southern Norway, near Langesund fiord.

Leucophane. A complex silicate of the composition $NaF.3BeO.3CaO.5SiO_2$ with 10.3 per cent BeO. It is found in the southern part of Norway, near Langesund fiord.

Meliphanite. A complex silicate, somewhat similar to leucophane, of the composition $NaF.2BeO.2CaO.3SiO_2$ with 13.1 per cent BeO. It is found in Norway, near Langesund fiord.

Trimerite. A complex silicate of the composition $(Mn,Ca)_2SiO_4.Be_2SiO_4$ with 16.6 per cent BeO. It is found in Sweden, at Vermland.

MARKETS AND PRICES

In recent months there has been some inquiry for beryl from abroad, and it is understood that foreign buyers have been paying in the neighborhood of \$60 a short ton f.o.b. New York. However, there can not be said to be a regular market price for beryl in this country, and sales are probably a matter of bargaining. As stated before, high freight rates (\$17 a ton on full carloads and \$50 a ton on less than carload lots) have made it difficult to market South Dakota material in the East. The demand in the United States, however, is small—all less than carload lots—and much of the beryl marketed in the East has come from New York state.

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THE NEW TARIFF AND NONMETALLIC PRODUCTS

The Tariff Act of 1930 contains the following schedules for various rock products:

Par. 20. CHALK OR WHITING or Paris white: Dry, ground, or bolted, four-tenths of 1 cent per lb.; precipitated, 25% ad valorem; ground in oil (putty), three-fourths of 1 cent per lb.; put up in the form of cubes, blocks, sticks, or disks, or otherwise, including tailors', billiard, red, and manufactures of chalk not specially provided for, 25% ad valorem.

Par. 49. MAGNESIUM: CARBONATE, precipitated, 1½ cents per lb.; manufactures of carbonate of magnesia, 2 cents per lb.; *chloride, anhydrous*, 1 cent per lb.; chloride, not specially provided for five-eighths of 1 cent per lb.; *sulphate* or *Epsom salts*, three-fourths of 1 cent per lb.; oxide or calcined magnesia, 7 cents per lb.

Par. 67. BARYTES ore, crude or unmanufactured, $4 per ton; ground or otherwise manufactured, $7.50 per ton; precipitated *barium sulphate* or blanc fixe, 1¼ cents per lb.

Par. 73. OCHERS, *siennas* and *umbers*, crude or not ground, one-eighth of 1 cent per lb.; washed or ground, three-eighths of 1 cent per lb.; *iron-oxide* and *iron-hydroxide pigments* not specially provided for, 20% ad valorem.

Par. 74. SATIN WHITE and precipitated calcium sulphate, one-half of 1 cent per lb.

Par. 85. STRONTIUM: CARBONATE, precipitated, nitrate and oxide, 25% ad valorem.

Par. 201. (a) BATH BRICK, CHROME BRICK, and FIRE BRICK, not specially provided for, 25% ad valorem; magnesite brick, three-fourths of 1 cent per lb. and 10% ad valorem.

(b) All other BRICK, not specially provided for: Not glazed, enameled, painted, vitrified, ornamented or decorated in any manner, $1.25 per thousand; if glazed, enameled, painted, vitrified, ornamented, or decorated in any manner, 5% ad valorem, but not less than $1.50 per thousand.

Par. 203. LIMESTONE (not suitable for use as monumental or building stone), crude, or crushed but not pulverized, 5 cents per 100 lb.; LIME, not specially provided for, 10 cents per 100 lb., including the weight of the container; HYDRATED LIME, 12 cents per 100 lb., including the weight of the container.

Par. 204. CRUDE MAGNESITE, fifteen thirty-seconds of 1 cent per lb.; caustic calcined magnesite, fifteen-sixteenths of 1 cent per lb.; dead burned and grain magnesite, and periclase, not suitable for manufacture into OXYCHLORIDE CEMENTS, twenty-three fortieths of 1 cent per lb.

Par. 205. (a) PLASTER ROCK OR GYPSUM, ground or calcined, $1.40 per ton.

(b) Roman, PORTLAND and other hydraulic CEMENT or CEMENT CLINKER, 6 cents per 100 lb., including the weight of the container; white nonstaining portland cement, 8 cents per 100 lb., including the weight of the container.

(c) KEENE'S CEMENT, and other cement of which gypsum is the component material of chief value: Valued at $14 per ton or less, $3.50 per ton; valued above $14 and not above $20 per ton, $5 per ton; valued above $20 and not above $40 per ton, $10 per ton; valued above $40 per ton, $14 per ton.

(d) OTHER CEMENT, not specially provided for, 20% ad valorem.

Par. 206. PUMICE STONE, unmanufactured, valued at $15 or less per ton, one-tenth of 1 cent per lb.; valued at more than $15 per ton, one-fourth of 1 cent per lb.; wholly or partly manufactured, three-fourths of 1 cent per lb.; manufactures of pumice stone, or of which pumice stone is the component material of chief value, not specially provided for, 35% ad valorem.

Par. 207. CLAYS or EARTHS, unwrought and unmanufactured, including common blue clay and Gross-Almerode glass pot clay, not specially provided for, $1 per ton; wrought or manufactured, not specially provided for, $2 per ton; BENTONITE, unwrought and unmanufactured, $1.50 per ton; wrought or manufactured, $3.25 per ton; china clay or kaolin, $2.50 per ton; CRUDE FELDSPAR, $1 per ton; BAUXITE, crude, not refined or otherwise advanced in condition in any manner, $1 per ton; FULLER'S EARTH, unwrought or unmanufactured, $1.50 per ton; wrought or manufactured, $3.25 per ton; clays or earths artificially activated with acid or other material, one-fourth of 1 cent per lb. and 30% ad valorem; SILICA, CRUDE, not specially provided for, $3.50 per ton; FLUORSPAR, containing more than 97% of calcium fluoride, $5.60 per ton; containing

not more than 97% calcium fluoride, $8.40 per ton; sand, containing 95% or more of SILICA and not more than six-tenths of 1% of oxide of iron and suitable for use in the *manufacture of glass*, $2 per ton.

Par. 208. (a) MICA, UNMANUFACTURED; valued at not above 15 cents per lb., 4 cents per lb.; valued at above 15 cents per lb., 4 cents per lb. and 25% ad valorem.

(b) MICA, cut or stamped to dimensions, shape or form, 40% ad valorem.

(c) MICA FILMS and splittings, not cut or stamped to dimensions: Not above twelve ten-thousandths of an inch in thickness, 25% ad valorem; over twelve ten-thousandths of an inch in thickness, 40% ad valorem.

(d) MICA FILMS and splittings cut or stamped to dimensions, 45% ad valorem.

(e) MICA PLATES and built-up mica, and all manufactures of mica, or of which mica is the component material of chief value, by whatever name known, and to whatever use applied, and whether or not named, described or provided for in any other paragraph of this act, 40% ad valorem.

(f) UNTRIMMED phlogopite MICA from which no rectangular pieces exceeding 2 inches in length or 1 inch in width may be cut, 15% ad valorem.

(g) MICA WASTE and scrap, valued at not more than 5 cents per lb., 25% ad valorem; mica waste and scrap valued at more than 5 cents per lb. shall be classified as mica, unmanufactured.

(h) MICA, ground or pulverized, 20% ad valorem.

Par. 209. TALC, steatite or soapstone, and French chalk, crude and unground, one-fourth of 1 cent per lb.; ground, washed, powdered or pulverized (except toilet preparations), 35% ad valorem; cut or sawed, or in blanks, crayons, cubes, disks or other forms, 1 cent per lb.; manufactures (except toilet preparations), of which talc, steatite or soapstone, or French chalk, is the component material of chief value, wholly or partly finished, and not specially provided for, if not decorated, 35% ad valorem; if decorated, 45% ad valorem.

Par. 213. GRAPHITE or plumbago, crude or refined: Amorphous, 10% ad valorem; crystalline lump, chip or dust, 30% ad valorem; crystalline flake, 1 65/100 cents per lb. As used in this paragraph, the term "crystalline flake" means graphite or plumbago which occurs disseminated as a relatively thin flake throughout its containing rock, decomposed or not, and which may be or has been separated therefrom by ordinary crushing, pulverizing, screening or mechanical concentration process, such flake being made up of a number of parallel laminae, which may be separated by mechanical means.

Par. 232. (a) MARBLE, BRECCIA and ONYX, in block, rough or squared only, 65 cents per cu. ft.; marble breccia and onyx, sawed or dressed, over two inches in thickness, $1 per cu. ft.

(b) SLABS and PAVING TILES of marble, breccia or onyx: Containing not less than four superficial inches, if not more than one inch in thickness, 8 cents per superficial foot; if more than one inch and not more than one and one-half inches in thickness, 10 cents per superficial foot; if more than one and one-half inches and not more than two inches in thickness, 13 cents per superficial foot; in addition thereto on all the foregoing, if rubbed in whole or in part, 3 cents per superficial foot, or if polished in whole or in part (whether or not rubbed), 6 cents per superficial foot.

(c) MOSAIC CUBES of marble, breccia or onyx, not exceeding two cubic inches in size, if loose, one-fourth of 1 cent per lb. and 20% ad valorem; if attached to paper or other material, 5 cents per superficial foot and 35% ad valorem.

FREE LIST

Par. 1616. ASBESTOS, unmanufactured, ASBESTOS CRUDES, FIBERS, STUCCO, and SAND and REFUSE CONTAINING not more than 15% of foreign matter.

Par. 1645. CHALK, crude, not ground, bolted, precipitated or otherwise manufactured.

Par. 1743. PLASTER ROCK or GYPSUM, crude.

Par. 1775. STONE and SAND: BURRSTONE in BLOCKS, rough or unmanufactured; QUARTZITE; TRAPROCK; ROTTENSTONE, TRIPOLI, and SAND, crude or manufactured; SILICA; CLIFFSTONE, FREESTONE, GRANITE and SANDSTONE, unmanufactured, and not suitable for use as monumental, paving or building stone; all the foregoing not specially provided for.

CRYSTALLINE TALC[1]

Operations in California of the Pacific Coast Talc Company

By Frank R. Wicks[2]

Talc, a product of desert mining, is perhaps one of the most widely used of the natural, nonmetallic minerals. In powdered form, in various grades and mixtures, talc is required in a great variety of industries. It is an essential ingredient in many of the most generally used drug supplies and cosmetics.

Pure talc is a white and rather soft mineral having a distinctly smooth, velvet-like feel and a pearly luster. Chemically pure talc is a crystalline, hydrous magnesium silicate, one of the most inert or inactive chemical combinations known in nature. This chemical stability adds much to the utility of talc in many manufacturing processes. The associated mineral, tremolite, an anhydrous calcium-magnesium silicate, also white and crystalline, has many of the desirable attributes of talc.

One of the most interesting and extensive deposits of white talc in the United States is found in the northeasterly portion of San Bernardino County, California, about seven miles northeasterly from the old desert town of Silver Lake, on the Tonopah & Tidewater Railroad, and about 10 miles north of the Arrowhead Highway. This is believed to be the only workable deposit of crystalline talc on the North American continent. The property is operated by the Pacific Coast Talc Company, under the management of George Ames, of Los Angeles. It has been a continuous producer of both crystalline talc and tremolite for over 10 years and was operated intermittently for several years prior to that time. The products are marketed under the trade name 'Silver,' derived from the near-by Silver Lake, which is the sink of the Mojave River and other intermittent desert streams.

Structurally, the talc and tremolite occur together as a large vein, which has a strike of 75 to 80 degrees east, and an average dip of 55 to 60 degrees south. Granite predominates as a footwall rock. Granodiorite and pegmatite are the chief hanging-wall rocks. There is an occasional showing of serpentine. The vein consists of a series of huge lenses connected by relatively short and narrow stringers of talc. The lenses have no regularity as to location or dimensions, but are often 75 to 100 feet in length and height and have thicknesses up to eight or 10 feet. Extensive faulting has occurred during and subsequent to the formation of the lenses, with the result that the vein seems to double upon itself both horizontally and vertically, to the extent that one lens may party overlap another with a rib of waste rock between. This sometimes produces the appearance of two veins, separated by three or four feet of diorite of pegmatite, but having an aggregate width of 18 to 20 feet of talc.

The average mining width of the whole vein is estimated at five to six feet, but as the work progresses there is a definite tendency for the vein to widen with increased depth. Whether or not this gradual increase in width will continue below the present lowest workings

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remains to be seen. In some places the full width of the vein is clean talc, whereas other places show a band of tremolite alongside of the talc occupying as much as half of the total width of the vein, with an occasional thin streak of silica or silicified limestone along the footwall. In any case the inclosing walls are hard and tight and are frequently slickensided by fault movement, so that it is easily possible to mine talc or tremolite separately and without contamination from waste rock. The relative softness of the white minerals is an important factor in this respect, as only light blasting is required.

The entire deposit is probably the result of complete or partial alteration of tremolite, which in turn had its origin in either serpentine or olivine. These geologic changes seem to have resulted from intense structural pressure at relatively moderate temperatures and accompanied by sufficient water vapor to permit the hydration of the talc mineral. The proportion of unaltered tremolite in the vein seems to be less with increasing depth below the surface. Throughout the deposit the talc shows the distinct crystalline structure so noticable in tremolite, but the talc crystals are much smaller and softer than the crystals of the parent rock. Under the microscope the tremolite crystals are seen to be oblique prisms, while the talc prism has a right-angle base.

Mining operations are conducted through a main tunnel now about 2000 feet long, which will ultimately reach a length of over a mile. This tunnel connects with the old main shaft at a point 220 feet below the surface. The shaft, not used during the past five years, is now being extended 150 feet below the tunnel level, on the incline of the vein, in preparation for deeper mining. Above the main tunnel several of the stopes have extended through to the surface, about 200 feet as an average. These now furnish sufficient ventilation for the workings. The mine is dry throughout, which is a great advantage in handling this mineral.

Between the various lenses of talc and tremolite are sections of the vein where the width of the talc is insufficient for profitable mining. As these portions serve for supporting the hanging wall, the amount of mine timber required is thus limited to only a few heavy stulls, an occasional tunnel set, and the supports for chutes in the principal stopes. For convenience in mining and to prevent the alternate development of heavy ground pressure, most of the old stopes adjacent to the main haulageway are refilled with waste from exploratory work. The main shaft is equipped with a Fairbanks Morse & Co., single-drum hoisting engine. This is not now used, but will be again required for deeper mining. Small Sullivan air hoists, set on the tunnel level, are being used for development work below the tunnel. Two winzes, about 500 feet apart, have been sunk 125 feet below the tunnel, and both are in talc of mining width all the way down.

All the talc, which is given a preliminary sorting as mined, is trammed out through the tunnel in one-ton cars. Bins at the surface are arranged for separate storage of the various grades, each bin having a capacity of 50 to 60 tons. From the bins the talc is drawn into trucks for hauling to the railroad, each grade being shipped separately. The shipping point is known as Talc Station, on the Tonopah & Tidewater Railroad, which connects with the Union Pacific at Crucero, and

with the Santa Fe at Ludlow, California, thus affording choice of routes to Los Angeles.

The truck road distance from the mines to Talc Station is six miles, straight across a sloping alluvial plain adjacent to Silver Lake. By constant dragging with a light steel road drag chained behind the truck, the road is kept in such condition that 13 to 14 tons can be hauled per trip on a six-wheel White truck. The truck with this load coasts at fairly good speed from the loading bins to within about a mile of the railroad siding, before any power is required. This is interesting because the cost of hauling has thus been reduced to 11 cents per ton-mile, including depreciation charges on the truck, and also including the cost of road work, loading and unloading talc, and the back haul of water and fuel for the mines. The cost per truck trip is now about the same as for the four-wheel truck formerly used, which hauled six tons per trip, over what was considered a good average road to the same station.

Crude talc and tremolite are shipped in box cars to the grinding plant of the Pacific Coast Talc Company, at 2149 Bay Street, Los Angeles. No talc is sold in the crude form, principally because the proper selection and preparation of talcs for various specific uses are important, and require skill and experience to accomplish uniform grading and grinding. The principal equipment in the Los Angeles plant consists of a No. 2½ Wheeling crusher and a five-roller, high-side, Raymond impact pulverizing mill, with air-float arrangement. There is also such accessory equipment as is required for conveying, sorting, elevating, screening, sacking, and storing. Means are also provided for making such physical and chemical tests as are necessary for correct grading and sizing of the talc.

The plant has floor space for storage of more than one thousand tons of sacked material, and sufficient trackage to permit the simultaneous loading or unloading of three railroad cars, as well as facilities for truck loading for local and harbor shipments. Thus immediate shipment of carload lots of almost any grade or size can usually be made from stock when desired. The talc and talc-tremolite mixtures are made up in five standard grades, each being for certain specific purposes, and each ground to a certain predetermined fineness which has been found most suitable for that use.

All grades are packed in 100-, 125- and 200-pound bags, either with or without paper liners, as the market requires. The plant is equipped to pack in wooden barrels or in paper bags on special order. Jute bags with paper liners are used for all ocean shipments and for all talc to be used in the cosmetic and drug trades. Cotton bags have been the most satisfactory for the greater part of the local business. The standard of fineness for most uses of talc is the 200-mesh screen, and the principal portion of the grinding is 99.5 to 99.7 per cent through this screen. Coarser grinding is standardized at 75, 90 and 95 per cent through 200 mesh, and finer grinding by similar percentages through a 325-mesh screen.

Accurate control of the fineness of grinding is essential for the production of uniform products, and this has been thoroughly worked out. The fineness is checked by screen tests and by microscopic measurement

when necessary. In this way it is possible to make reasonably accurate measurement of grain sizes down to 0.001 in., or 0.025 mm. In some instances it is important to know the proportion of various sizes finer than a given mesh, as well as to determine the size of the largest particles. For this purpose the microscope has proven very useful.

The chemical quality of the talc is determined by quick acid tests, made every hour or oftener if necessary, supplemented by more detailed analyses of car-lot quantities. Color tests are made frequently, by comparison with established standards which are rigidly adhered to in classifying different grades of talc. In these tests it is of interest to note the accuracy of color perception developed by men in the plant, who become so experienced that they can detect color variation in products that seem absolutely white to the untrained eye. Other physical tests are made at frequent intervals to insure freedom from grit or other undesirable elements in the various grades where such matters are important factors. Unusual care is exercised at the mines and in the transportation and handling at the plant, to insure absolute cleanliness of all products.

For the manufacture of cosmetics and talcum powders, and for use in the drug trades, a very white, selected talc is furnished, packed in paper-lined bags. The paper liner is closed securely and the bag is then sewed so that no possible contamination can occur, either by absorption of odors or vapors during shipment, or by the sifting in of foreign materials. This talc must be of such quality that it does not contain grit or acid-soluble materials, and that it does not cause the skin to become shiny or glossy when applied to the face, and it must have the proper capacity to absorb and hold perfumes.

Crystalline talc and talc-tremolite mixtures find extensive use in the ceramic industry for the manufacture of white tile of various kinds and for wall and floor tile, both glazed and unglazed. Certain of these uses are covered by patents. In most ceramic work the talc is used in combination with small amounts of plastic clay. For the production of white ware, the color and texture of the talc materials is important. Fineness of grinding must be accurately controlled. When properly prepared and compounded, the crystalline talc can be fired with practically no shrinkage or warping, and the ware is of such texture as to take and hold a good glaze. It is also said to have good dielectric strength, and thus is much used in making electrical porcelains.

In the manufacture of rubber products of many kinds the crystalline talc is extensively used, not only for the dusting of molds and finished goods, but sometimes incorporated in the product itself. Automobile tires and tubes require the greater proportion of the total used in this industry. Some rubber manufacturers prefer a grade of talc not so intensely white as that required in other trades.

On account of the smoothness of powdered crystalline talc, it serves as an important ingredient in many dry lubricants and heavy oil lubricants. The lubricating quality or property of the dry powder is also utilized in foundry molding, in handling timber, and many other ways.

One of the most interesting developments accomplished by the technical staff of the Pacific Coast Talc Company is the production of Silver

Crystalline Talc concrete admixture, for use in Portland-cement concrete. This product was placed on the market four years ago, after about two years of testing and investigation, and has now come into general use in the better class of concrete work. The crystalline talc selected for this particular use possesses three properties which seem essential to a successful concrete admixture. It is chemically inert, has excellent lubricating qualities, and is highly water resistant. The Silver talc admixture is used in proportions of about three pounds per sack of cement, or 12 to 18 pounds per cubic yard of concrete, replacing about an equal weight of water in the mix. It serves to produce a workable, plastic mixture and tends to reduce or prevent segregation of the component parts by increasing the pasty condition of the mix. Its use aids in procuring high-strength concrete and in insuring a uniformly smooth exterior where the concrete is to be left exposed. It has been incorporated in concrete throughout some of the largest buildings in the West. In the manufacture of this product, also, the character of the grinding is fully as important as the selection of the correct crude materials.

Among the miscellaneous uses found for talc, particularly that of the crystalline variety such as the Silver talcs, the manufacture of paper products and paint are worthy of special mention. These industries have gradually increased the use of white talcs in place of the darker soapstone materials. Even in the colored products—such as building paper, roofing paper, and composition roofing and in cardboard products—the crystalline talc seems to be well liked.

The Pacific Coast Talc Company does not purchase or handle talcs other than those produced at the Silver Lake mines; but at the Los Angeles plant the company handles a limited tonnage of other white, nonmetallic minerals, such as whiting, mica-schist, and bentonite clays, principally for the convenience of car-lot purchasers of talcs who also use smaller amounts of other natural materials.

The successful production and marketing of talc involves many of the usual problems of mining and processing such as are encountered in metal mining, plus the intricate control of dry, air-float grinding, and the talc business also involves a more or less detailed study of the various industries in which talcs find application.

As the talc industry has only slight tariff protection, the crystalline talc of California must compete on a cost and quality basis with Canadian talc and with the talcs produced in several European countries. Such competition can only be met by maintenance of uniformly high quality and by the most rigid economies in production and sales costs. The mining and marketing of talc should not be undertaken by anyone without prior experience in the particular trades to which the talc is sold as well as the ordinary experience of nonmetallic mining.

DECORATIVE EFFECTS IN CONCRETE[1]

By Frank R. Wicks [2]

A noteworthy example of the pleasing and effective architectural results that may be accomplished by poured-in-place ornamentation is to be seen in the concrete work at the Memorial Terrace Mausoleum in Forest Lawn Memorial Park, near Glendale, California. The first units of this mausoleum were erected a few years ago, at which time the exterior of the first story was finished with cut-stone blocks. However, subsequent developments in the production and placement of concrete for exterior finish and for decorative work made it possible to use this method for the remainder of the structure. Important factors in the success of the work were careful selection and grading of aggregate and the use of a talc mixture in the concrete to produce the high degree of workability and plasticity necessary to insure the complete filling of forms. The second and third stories of the building, which are also a portion of the original concrete structure, were given a veneer coat of eight inches of new concrete. This was designed to harmonize with the newer portion of the building above, as may be seen in Fig. 1.

The front of the building presents an impressive appearance on account of the long, unbroken, indented belt-courses and the bracketed coping along the top of each wall. Just above the large circular window and below the battlement at the center of the upper story is a frieze made up of a combination of triangles and diamond-shaped blocks. The semicircular arched windows and doors on the second and third floors have a wide casing decorated with small rectangular blocks, while the upper circular arches have plain casings with a border of small triangles above. All of these designs were built into the forms with wooden blocks and then poured monolithic with the walls.

The pointed arches have a plain detail casing, also poured integral with the wall, with recesses to receive cut-stone ornamentation. Where the stone is to be placed, the concrete was poured with a slightly honeycombed surface to assure a better bond for the mortar. Elsewhere the concrete was poured smooth. All openings are designed to receive bronze frames or sash for leaded-glass windows.

Forms of plaster—The circular windows, of which there will be several in the completed structure, were produced by the use of plaster castings for forms. These plaster shapes were molded over wooden frames (Fig. 2) and then given a coat of shellac before being placed. Concrete poured against these plaster forms shows an extremely smooth and uniform surface, and the shellac effectively prevents bond between the concrete and the form. Each form is used only once, and each circular window is of a different design.

Another result of the use of the plaster-cast form is to be seen in brackets placed on two sides of the building, shown in Fig. 3. A pattern of hand-carved wood was used for making the plaster molds, which were then assembled in a long boxlike form and placed into the wall forms. Thus the wall and brackets and the coping could all be poured

[1] Reprinted from Engineering News-Record, July 17, 1930.
[2] Consulting Mining and Industrial Engineer, Los Angeles, California.

Fig. 1—Forest Lawn Mausoleum, Glendale, California. Photo by Whittington, Los Angeles.

at one time. When the photograph was taken the work had not yet been washed or brushed down.

Among the various designs of copings, etc., there were three styles of smaller brackets which required carved-wood patterns from which plaster molds were made. By exercising care in placing the concrete in these molds and by varying the amount of tamping, it was found that some brackets could be cast smooth and others with a slightly

Fig. 2—Making a plaster-cast form for a circular window. Plaster was molded over a wooden frame and then given a coat of shellac to eliminate bond with concrete. Photo by Whittington, Los Angeles.

pitted or honeycombed surface. This was done to lend variety to the whole design, and the results were very satisfactory. The pitted surfaces were not sufficiently roughened to expose the aggregate.

In one instance, where the design of the bracket was curved and fluted, having the shape of half an acorn, the mold used was partly plaster and partly wood, all made from a hand-carved pattern. These smaller brackets of intricate design were used chiefly on interior ornamentation work.

The concrete in walls and columns and in the main beams and most of the exterior decorative work, is a 1:2½:3½ mix, containing 2½ to three pounds of talc admixture per sack of cement. The maximum size of rock used in this class of work was three-quarter inch. Tests showed a seven-day strength of 2230 pounds per square inch and a 28-day strength of 3450 pounds.

In the interior of the building, the ceilings and many of the beams are of exposed concrete, although some portions of the interior walls are covered with marble. In some of the corridors and larger rooms

the arched ceiling beams are of exposed concrete with a variety of detail, consisting of large and small panels and geometrical designs in deep relief. One of these designs is shown in Fig. 4. This photograph was taken while the forms were being removed. In the smaller rooms and at the ends of the corridors where the ceilings are flat instead of arched the entire ceiling area is set off in square panels, as shown in Fig. 5. Each of the rooms and each bay in the main corridors possesses a slightly different design of panel work, the variation being accomplished by different designs of molding, by difference in depth of relief, by change in the size of the individual panel or by variation in geometrical design. All of this work was done by poured-in-place concrete, using a pea-gravel mix of the proportions of $1:1\frac{1}{2}:3$, containing the talc admixture in amounts equal to about 4 per cent of the weight of the cement used. In a few places where the forms were rather more difficult to fill, the proportion of the admixture was increased to 6 per cent. In order to get good results on such construction as is shown in the arched ceiling beams, a relatively dry mix was required, but one that was both plastic and workable. The concrete had to be plastic

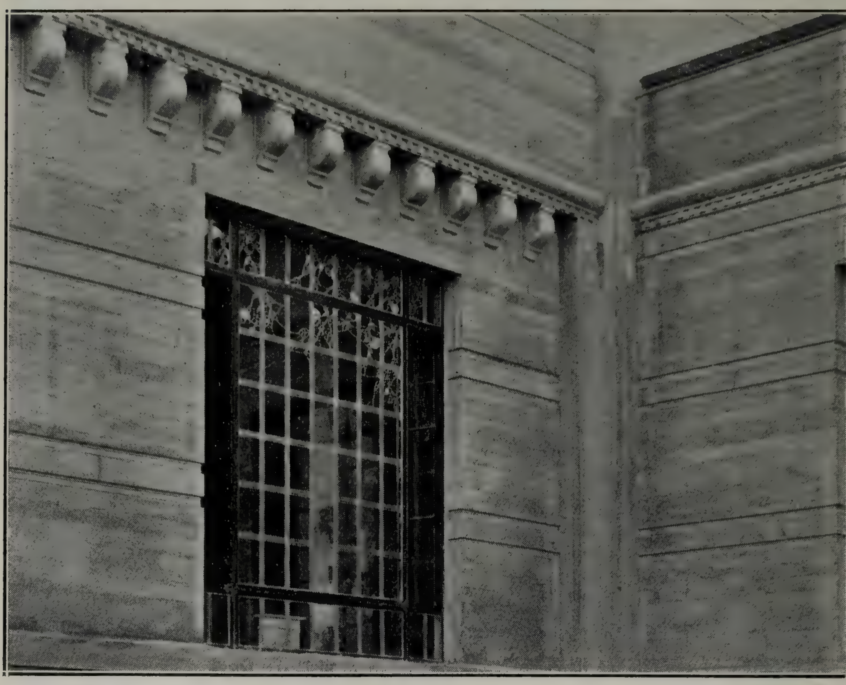

Fig. 3—Poured-in-place brackets made with plaster-cast forms.
Photo by Whittington, Los Angeles.

enough to be worked into every portion of the form and stiff enough to hold the arched shape at the top of the beams without creeping. For this work the talc admixture proved very valuable, as it has the property of softening and lubricating the mix and at the same time reducing the amount of mixing water required, thus eliminating substantially all of the water pockets and sand streaks on the surface of the completed concrete. No precast panels or precast sections were used and no

patching, brush-coating or chisel work was required after the removal of the forms. The ornamental concrete work was brushed down with a wire brush, washed thoroughly with water and allowed to dry slowly, after which it was ready for painting and decorating. In no case was a cement brush coat or plaster finish used.

It will be noted that where the ceilings and beams were to be left exposed no tie rods or form ties were used, thus avoiding any necessity for patching and also avoiding the possibility of discoloration of paint by iron rust. In such places and also where it was desirable to avoid showing the marks of end cuts in form lumber, the forms were built of one-inch stock, with ends glued and with the sides held together with wiggle-nails. These forms were then inclosed in form boxes made of

Fig. 4—Ceiling beams immediately after forms were removed. Double forms were used for this work, the interior set having glued joints. By the use of this double set of forms it was not necessary for wire ties to pass through the concrete. The outer set of forms constituted the structural support. Photo by Whittington, Los Angeles.

two-inch planking to carry the weight. Form lumber was all vertical-grained, usually surfaced on one side and two edges, with the rough side placed to the wall. This gave a better texture to the wall than would have been obtained by pouring against the planed side, and also served to contrast the flat surfaces when viewed alongside of the rounded or milled shapes, which, because of the care exercised, were particularly smooth.

For the production of the various shapes of panels, brackets, etc., a great variety of milled moldings was required. A sketch of each shape was furnished to the mill, and the moldings were delivered to the job in stock lengths. All formwork, including the plaster castings, panels,

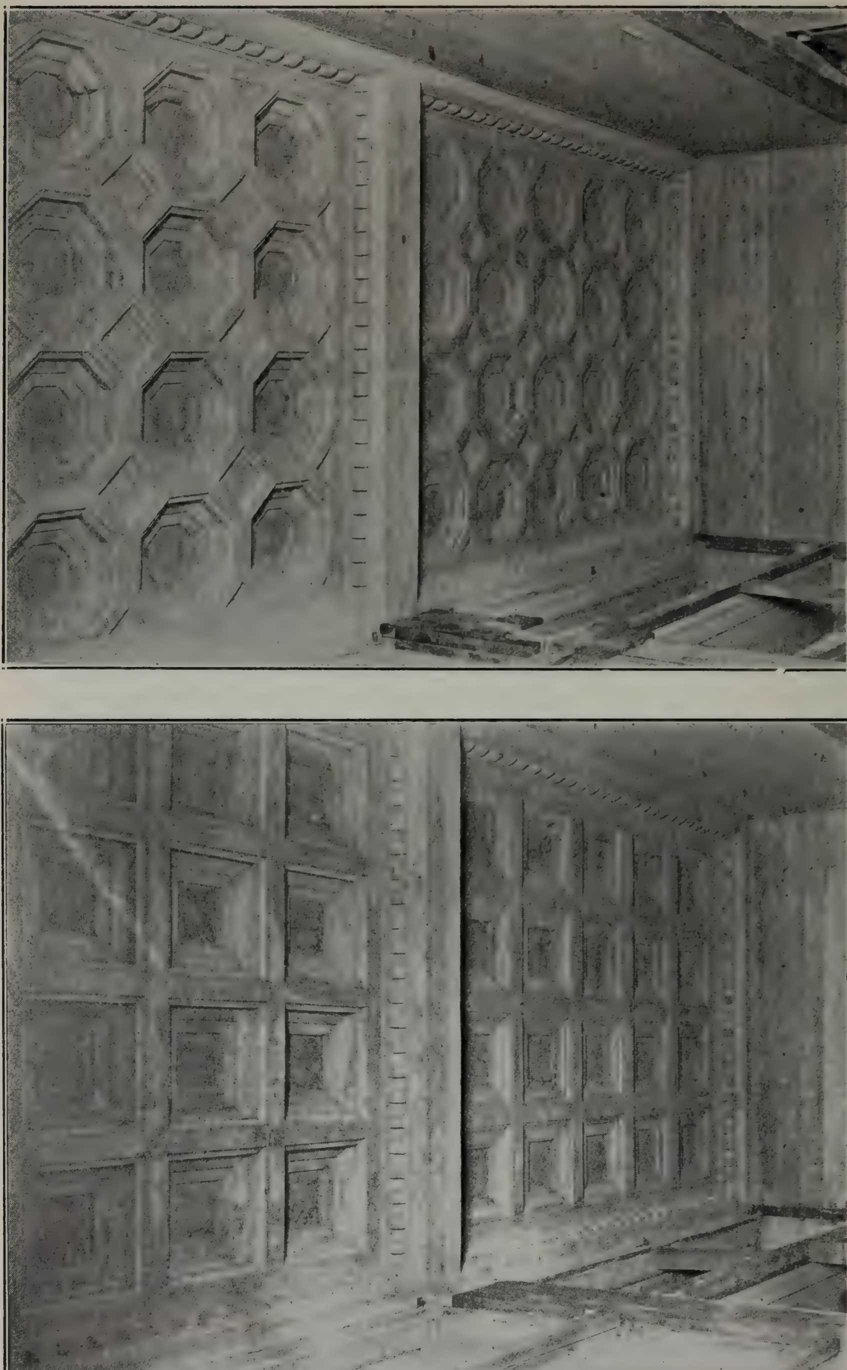

Fig. 5—Two designs of poured-in-place ceilings. Photos by Whittington, Los Angeles.

etc., was done at the building. Considerable use was made of a composition wood in the forms for the flat surfaces in the panel work, and for the indented-panel effect produced in the concrete in the sides and top of each crypt. This material was easy to work, could be cut and mitered with a knife when desired, and was found very durable.

The architectural and structural designs of the mausoleum were prepared by the architectural department of the Forest Lawn Properties Association, owner and builder. This work was under the direction of David C. Allison, the consulting architect, and E. W. Cunningham, structural engineer. The field work was handled by Howard J. Wallace, chief engineer of the Forest Lawn Association, and the erection work was under the direct supervision of Clyde A. Maclaren, construction superintendent.

ADMINISTRATIVE

WALTER W. BRADLEY, State Mineralogist

Personnel.

There have been no changes nor additions of personnel to be noted during the past three months.

New Publications.

Mining in California (quarterly), July, 1930, being Chapter 3 of Mineralogist's Report XXVI. Price 25 cents. Contains reports on the mineral resources of San Bernardino and Yuba counties; a special article on "Commercial Grinding Plants in California"; and a summary report of the progress of geological survey work in California including an index map of the State.

Commercial Mineral Notes, Nos. 91, 92, 93, October, November, December, 1930, respectively. These 'notes' contain the lists of 'mineral deposits wanted' and 'minerals for sale' issued in the form of a mimeographed sheet; monthly. It is mailed free to those on the mailing list for MINING IN CALIFORNIA.

As an evidence of the interest in mines and minerals now showing considerable activity, this mimeographed 'sheet' has had to be expanded to two pages for the current issues.

Mails and Files.

The Division of Mines maintains, in addition to its correspondence files and the library, a mine file which includes original reports on the various mines and mineral properties of all kinds in California.

During each quarterly period there are several thousand letters received and answered at the San Francisco office alone, covering almost every phase of prospecting, mining and developing mineral deposits, reduction problems, marketing of refined products and mining law. In addition to this, hundreds of oral questions are answered daily, both at the main office and the district offices, for the many inquirers who come in for personal interviews and to consult the files and library.

MINERALS AND STATISTICS

Statistics, Museum, Laboratory

HENRY H. SYMONS, Statistician and Curator

STATISTICS

CALIFORNIA'S MINERAL PRODUCTION IN 1930

The total value of the mineral production of California for the year 1930, just closed, is conservatively estimated by the statistical division, to have been $347,797,000. This is, in part, detailed in the tabulation below, but, as there are more than fifty mineral substances on California's commercial list, it is impracticable at this early date to obtain definite figures on other than the more important items. The blank report forms are being mailed to the operators in all mineral lines, and the detailed and complete report will be compiled and published later.

The estimated total of $347,797,000 is a decrease of approximately $84,450,000 from the value of 1929 production. The decrease is due mainly to petroleum and in a smaller measure to cement, copper, structural materials in general, industrial materials, and salines. Increases in value were shown by natural gas, gold, and lead. There was a decrease of approximately 64,000,000 barrels in quantity of crude oil, with the average value per barrel practically the same as for 1929. Around 85 per cent of the crude oil at present produced in California is above 20° B., some testing as high as 60° B.; while the low-grade ranges down to 9° B. Current prices range from 55 cents a barrel for 14°–20° crude in the San Joaquin Valley fields, to $2.08 for 43° crude in the Athens-Rosecranz-Dominguez section. There was an increase in quantity of natural gas utilized.

Receipts of bullion at the mint and smelters show an increase in the gold yield of about $500,000 compared with 1929, this being due to increased activity in the principal lode mines as the output from the dredges showed a decrease. Lead showed an increase in the face of decreased prices of this metal. Silver registered an increased output, but its total value was less than that of 1929. Copper showed a decrease in both quantity and value as most of the principal producers of that metal in the State closed down before the end of the year. Quicksilver remained about the same as the preceding year.

The structural group showed about a 20 per cent decrease throughout on account of lesser construction work during the year. The industrial and saline groups will show decreased totals.

The estimated values and quantities for 1930 are as follows:

$9,034,000	gold.
557,000	(1,445,000 fine ounces) silver.
3,238,000	(26,113,000 pounds) copper.
178,000	(3,423,000 pounds) lead.
1,155,000	(10,500 flasks) quicksilver.
125,000	other metals, including manganese, platinum, tungsten.
$251,000,000	(228,300,000 barrels) petroleum.
30,825,000	(425,000,000 M. cubic feet) natural gas.
16,862,000	(10,282,000 barrels) cement.
15,000,000	crushed rock, sand, and gravel.
4,500,000	brick and hollow building tile.
473,000	(45,000 tons) magnesite.
1,250,000	other structural materials including granite, lime, etc.
5,700,000	miscellaneous industrial minerals.
8,000,000	salines, including borates, potash, salt, soda, etc.
$347,797,000	

MUSEUM

The Museum of the State Division of Mines possesses an exceptionally fine collection of rocks and minerals of both economic and academic value. It ranks among the first five of such collections in North America and contains not only specimens of most of the known minerals found in California, but much valuable and interesting material from other states and foreign countries as well.

Mineral specimens suitable for exhibit purposes are solicited, and their donation will be appreciated by the State Division of Mines as well as by those who utilize the facilities of the collection.

The exhibit is daily visited by engineers, students, business men, and prospectors, as well as tourists and mere sightseers. Beside its practical use in the economic development of California's mineral resources, the collection is a most valuable educational asset to the State and to San Francisco.

LABORATORY

FRANK SANBORN, Mineral Technologist

Approximately 2000 samples were received and determined during the period of three months covered by this report. Samples were received from practically every county in the State.

In a mineralogical way, a sample of gillespite from Mariposa County was of interest, while those of economic importance consisted mainly of gold and silver ores from different sections of the State. High grade gold and silver ore was received from Humboldt County. Good grades of gold-silver ores were also received from counties which have been more or less steady producers of these metals.

LIBRARY

HERBERT A. FRANKE, Librarian

In addition to the numerous standard works, authoritative information on many phases of the mining and mineral industry is constantly being issued in the form of reports and bulletins by various government agencies.

The library of the Division of Mines contains some five thousand selected volumes on mines, mining and allied subjects, and it is also a repository for reports and bulletins of the technical departments of federal and state governments and of educational institutions, both domestic and foreign.

It is not the dearth of the latter publications, but rather a lack of knowledge of just what has been published and where the reports may be consulted or obtained, that embarrasses the ordinary person seeking specific information.

To assist in making the public acquainted with this valuable source of current technical information, MINING IN CALIFORNIA contains under this heading a list of all books and official reports and bulletins received, with names of publishers or issuing departments.

Files of all the leading technical journals will be found in the library, and county and State maps, topographical sheets and geological folios. Current copies of local newspapers published in the mining centers of the State are available for reference.

The library and reading room are open to the public during the usual office hours, when the librarian may be freely called upon for all necessary assistance.

OFFICIAL PUBLICATIONS RECEIVED

Governmental.

U. S. Geological Survey:

Bulletins:

Annual report of the Director of the Geological Survey to the Secretary ot the Interior for fiscal year ended June 30, 1930.
813–C. Mining in the Fortymile District, Alaska. By J. B. Mertie, Jr.
813–D. Notes on the Geology of Upper Nizina River, Alaska. By F. H. Moffit.
817. Boundaries, Areas, Geographic Centers, and Altitudes of the U. S. and the Several States. (2d Edition). By. E. M. Douglas.
821–A. A Graphic History of Metal Mining in Idaho. By C. P. Ross.
822–A. Geology and Mineral Resources of Parts of Carbon, Big Horn, Yellowstone, and Stillwater counties, Montana. By R. S. Knappen and G. F. Moulton.
822–C. Bituminous Sandstone Near Vernal, Utah. By E. M. Spieker.
824–A. Mineral Industry of Alaska in 1929 and Administrative Report. By P. S. Smith.

Professional Papers:

100. The Coal Fields of the U. S. By M. R. Campbell. Ohio. By J. A. Bounocker.
160. Geologic History of the Yosemite Valley. By F. E. Matthes.

Water-Supply Papers:

623. Part III, Ohio River Basin.
628. Part VIII, Western Gulf of Mexico Basins.
635. Surface Water Supply of Hawaii.
646. Part VI, Missouri River Basin.
647. Part VII, Lower Mississippi River Basin.
648. Part VIII, Western Gulf of Mexico Basins.
650. Part X, the Great Basin.
655. Surface Water Supply of Hawaii.

U. S. Bureau of Mines:

Bulletins:

Annual report of the Director of the Bureau of Mines to the Secretary of Commerce for fiscal year ended June 30, 1930.

332. Permissible Electric Mine Lamps. By L. C. Ilsley and A. B. Hooker.
323. Gas-Lift Method of Flowing Oil Wells. (California Practice). By H. C. Miller.
324. Zinc Smelting from a Chemical and Thermodynamic Viewpoint. By C. G. Maier.
329. Agglomeration and Leaching of Slimes and Other Finely Divided Ores. By J. D. Sullivan and A. P. Towne.

Technical Papers:

National Survey of Fuel Oil Distribution, 1929. By E. B. Swanson.

Questions and Answers for the Coal Fireman. By J. F. Barkley.

478. Production of Explosives in the U. S. During the Calendar Year 1929. By W. W. Adams and L. S. Gerry.
479. A Study of the Production of Activated Carbon from Various Coals and Other Raw Materials. By A. C. Fieldner, R. E. Hall, and A. E. Galloway.
488. Resistivity Measurements of Oil-bearing Beds. By F. W. Lee and J. H. Swartz.

Economic Papers:

3. Historical Summary of Gold, Silver, Copper, Lead and Zinc Produced in California, 1848 to 1926. By J. M. Hill.
10. Economic Relations of Silver to Other Metals in Argentiferous Ores. By C. W. Merrill.

Recent Articles on Petroleum and Allied Substances:

August, 1930.

September, 1930.

Mineral Resources of the U. S.:

Abrasive Materials in 1929. By O. Bowles.

Antimony in 1929. By P. M. Tyler.

Carbon Black in 1929. By G. R. Hopkins and H. Backus.

Clay in 1929. By J. Middleton.

Copper in 1928. By C. E. Julihn and H. M. Meyer.

Feldspar in 1929. By O. Bowles and J. Middleton.

Fuller's Earth in 1929. By J. Middleton.

Gold and Silver in 1928. By J. P. Dunlap.

Gold, Silver, Copper, Lead and Zinc in Arizona in 1928. By C. N. Gerry.

Gold, Silver, Copper, Lead and Zinc in Colorado in 1928. By C. W. Henderson.

Gold, Silver, Copper, Lead and Zinc in the Eastern States in 1929. By J. P. Dunlap.

Gold, Silver, Copper and Lead in South Dakota and Wyoming in 1928. By C. W. Henderson.

Gold, Silver, Copper, Lead and Zinc in Utah in 1928. By C. N. Gerry.

Gold, Silver, Copper, Lead and Zinc in Idaho and Washington in 1928. By C. N. Gerry.

Graphite in 1929. By J. Middleton.

Gypsum in 1929. By R. M. Santmyers and J. Middleton.

Iron Ore, Pig Iron and Steel in 1929. By H. W. Davis.

Magnesium and Its Compounds in 1929. By P. M. Tyler.

Platinum and Allied Metals in 1929. By H. W. Davis.
Silica in 1929.
Zinc in 1928. By E. W. Pehrson.

Reports of Investigations:

3030. Tests of Ampoules Filled with Palladium Salt Solution for Detecting Carbon Monoxide. By L. B. Berger and W. P. Yant.
3031. Acrolein as a Warning Agent for Detecting Leakage of Methyl Chloride from a Multiple Refrigeration System. By H. H. Schrenk, F. A. Patty and W. P. Yant.
3032. A Study of the Properties of Texas Polyhalite Pertaining to the Extraction of Potash. By H. H. Storch.
3033. The Action of Sulphur Dioxide on Manganese Oxides at Elevated Temperatures. By C. W. Davis.
3034. The Effectiveness of Different-sized Rock-dusts in Preventing Coal-dust Explosions in Mines. By G. S. Rice, H. P. Greenwald and H. C. Howarth.
3035. The Recovery of Oil from Sands by the "Gas Drive". By Joseph Chalmers, I. H. Nelson and D. B. Taliaferro.
3036. Tests of the Strength of Concrete Stoppings Designed to Resist the Pressure of Explosions in Coal Mines. By G. S. Rice, H. P. Greenwald and H. C. Howarth.
3037. Official Changes in the Active List of Permissible Explosives and Blasting Devices for September, 1930.
3038. Survey of Fuel Consumption at Refineries in 1929. By G. R. Hopkins.
3039. The Trauzl Block Strength of Dynamites. By N. A. Tolch and G. St. J. Perrott.
3040. The Response of Japanese Waltzing Mice and Canaries to Carbon Monoxide and to Atmospheres Deficient in Oxygen. By W. P. Yant, F. A. Patty, H. T. Schrenk and T. B. Gerger.
3041. Review of Fatalities in the California Petroleum Industry During the Calendar Year 1929. By R. L. Marek.
3042. Extinction of Methane Flames by Dichloro-Difluoro-Methane. By G. W. Jones and G. St. J. Perrott.
3043. The Use and Value of Air Analyses in Illinois Mines. By A. U. Miller.
3044. Coal-dust Explosions in Mines Caused by Direct Electrical Ignition. By G. S. Rice, H. P. Greenwald and H. C. Howarth.
3045. Concentration Tests on the Manganiferous Iron Ores of the Cuyuna District, Minnesota. By F. D. DeVaney and J. B. Clemmer.
3046. Official Changes in the Active List of Permissible Explosives and Blasting Devices for October, 1930.
3047. Method for Measuring Voids in Porous Materials. By J. D. Sullivan, G. L. Oldright and W. E. Keck.
3048. Study of High Manganese Slags in Relation to the Treatment of Low-grade Manganiferous Ores. By C. H. Herty, Jr., J. E. Carley and M. B. Royer.
3049. Concentration of Chromite. By H. A. Doerner.
3051. Hauling Coal Safely with Permissible Storage-Battery Locomotives. By C. W. Owings.
3052. Concentration Tests on Tailings from the Washing Plants of the Mesabi Range, Minnesota. F. D. DeVaney and Will H. Coghill.
3053. Official Changes in the Active List of Permissible Explosives and Blasting Devices for November, 1930.
3054. Fundamental and Applied Research on the Physical Chemistry of Steel Making. By C. H. Herty, Jr.
3055. Accelerated Laboratory Test for Determination of Slacking Characteristics of Coal. By A. C. Fieldner, W. A. Selvig and W. H. Frederic.
3057. Processes for Extracting Radium from Carnotite. By H. A. Doerner.
3058. Official Changes in the Active List of Permissible Explosives and Blasting Devices for December, 1930.
3063. Twenty-second Semiannual Motor Gasoline Survey. By E. C. Lane, E. L. Garton and A. J. Kraemer.
3071. Coal-mine Fatalities in November, 1930. By W. W. Adams and L. Chenoweth.

Information Circulars:

6306–a. Nomographs for Calculating the Second Derivatives of the Force of Gravity Potential Obtained by Observations Made with a Torsion Balance at Five Azimuths. Translated by W. Ayvazoglou from the original Russian of A. Stepanoff.

6326. Some Notes on Underground Transportation in Metal Mines. By Chas. F. Jackson.

6327. Mining Methods and Costs at the Consolidated Cortez Silver Mines, Cortez, Nevada. By George W. Hezzlewood.

6332. Mining Laws of Trinidad. By John W. Frey.

6333. The Cost of Accidents to Industry. By F. S. Crawford.

6334. Mining Laws of Australia. By John W. Frey.

6335. Notes on the Determination of Molybdenum. By H. A. Doerner.

6336. Mining Laws of Salvador. By A. D. Garman.

6337. The Specific Heat of Water Vapor at High Temperatures Derived from Explosion Experiments. By E. D. Eastman.

6338. Mining Laws of Uruguay (1884–1913). By A. D. Garman.

6339. Safety at the Mines of the Ford Collieries Co., Curtisville, Pa. By C. W. Jeffers.

6340. Mining Laws of Haiti. By A. D. Garman.

6342. Milling Practice at the Netta Mine of the Eagle Picher Lead Company at Picher, Oklahoma. By Frank W. Sansom.

6343. Milling Methods and Costs at the Concentrator of the United Verde Copper Company, Clarkdale, Arizona. By C. R. Kuzell and L. M. Barker.

6344. What the Mine Foreman Can Do to Prevent Injury from Falls of Roof in Coal Mines. By J. W. Paul.

6345. What the Superintendent of a Coal Mine Can Do to Prevent Injury from Falls of Roof. By J. W. Paul.

6346. Mining Laws of Canada. By John W. Frey.

6348. Method and Cost of Mining Hematite at the Eureka-Asteroid Mines on the Gogebic Range, Gogebic County, Minn. By O. M. Schaus.

6349. Industrial Safety Training at a Mining School. By E. H. Denny and G. M. Kintz.

6350. Undercut Block-Caving Method of Mining in Western Copper Mines. By E. D. Gardner.

6351. Safety at the Morenci Branch of the Phelps Dodge Corporation, Morenci, Arizona. By R. I. C. Manning and T. Soule.

6352. Explosions in Alabama Coal Mines. By F. E. Cash and H. B. Humphrey.

6353. Milling Practice at the White Bird Concentrator, Canam Metals Corporation, Picher, Oklahoma. By E. H. Crabtree, Jr.

6354. Fatalities in Alabama Coal Mines. By F. E. Cash and H. B. Humphrey.

6356. Method and Cost of Quarrying Limestone at the Speed Quarry of the Louisville Cement Company, Speed, Indiana. By H. D. Baylor.

6357. Methods and Costs of Treatment at the Calumet & Hecla Reclamation Plant. By C. Harry Benedict.

6358. Milling Methods and Costs at the Nacozari Concentrator of the Phelps Dodge Corporation, Nacozari, Sonora, Mexico. By E. H. Rose and W. B. Cramer.

6359. Milling Methods and Costs at the Black Hawk Concentrator, Hanover, New Mexico. By Ira L. Wright.

6360. Mining Methods and Costs at Tintic Standard Mine, Tintic District, Utah. By J. W. Wade.

6362. List of Permissible Self-Contained Oxygen Breathing Apparatus, Gas Masks and Hose Masks.

6363. Mining Laws of Italy. By E. P. Youngman.

6365. Titanium. By E. P. Youngman.

6366. Geophysical Abstracts, No. XVII. By F. W. Lee.

6367. Connection Between Physical Condition and Liability to Accidents of Metal Miners. By R. R. Sayers.

6368. Mining Practice at the Pecos Mine of the American Metal Company of New Mexico. By J. T. Matson and C. Hoag.

6370. Methods of Mining at the Black Rock Mine, Butte & Superior Mining Company, Butte District, Montana. By D. B. McGilvra and A. J. Healy.
6373. The Mineral Industry and the Young Engineer. By S. Turner.
6374. Recent Developments in the Mining Industry. By S. Turner.
6375. Specially Recommended Trailing Cable. By L. C. Ilsley.
6380. Mining Practices, Methods and Costs at Mine No. 5 of the Marquette Range, Michigan. By W. W. Graff.
6381. Feldspar. By O. Bowles and C. V. Lee.
6383. Mining Bituminous Coal by Stripping Methods. By Scott Turner, Director, and Bureau of Mines Staff.
6384. Mining Methods of the Rosiclare Lead and Fluorspar Mining Company, Rosiclare, Illinois. By A. H. Cronk.
6386. Deposits of Titanium-Bearing Ores. By E. P. Youngman.
6387. Bromine and Iodine. By Paul M. Tyler and Amy B. Clinton.
6388. Possible Utilization of Natural Gas for the Production of Chemical Products. By Harold M. Smith.
6390. Mining Practices, Methods, and Costs at Mine No. 4 of the Marquette Range, Michigan. By W. W. Graff.
6392. Conservation of Natural Gas in Relation to Some Recent Developments. By S. Turner.
6393. Geophysical Abstracts, No. XVIII. By F. W. Lee.
6395. Use of Thermodynamical Data to Study the Chemical Reactions of Metallurgical Processes. By R. S. Dean.
6396. Sources and Distribution of Major Petroleum Products, Atlantic Coast States, 1929. By E. B. Swanson.
6398. Holmes Safety Certificate Presentation. By Scott Turner.
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6401. Gallium, Germanium, Indium and Scandium. Alice V. Petar.
6403. Geophysical Abstracts No. XIX. By Frederick W. Lee.
6409. Accident Prevention in Coal Mining. By W. H. Forbes.
6415. Observations and Notes on the Effect of Methanol Antifreeze on Health. By R. R. Sayers and W. P. Yant.
6418. Men and Mines. By S. Turner.
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Part I, August, 1930.
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Serial No. 495. Seismological report, July, August, September, 1927.

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Bulletin No. 38. Physical Divisions of Northern Alabama. By. W. D. Johnston, Jr.
Bulletin No. 39. Statistics of the Mineral Production of Alabama for 1928. By J. Barksdale.
Museum Paper No. 9. Footprints from the Coal Measures of Alabama. By T. H. Aldrich, Sr., and W. B. Jones.

Museum Paper No. 10. Goniobases of the Vicinity of Muscle Shoals. By C. Goodrich.

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Bulletin 3. Geology of the Arkansas Paleoxoic Area. By C. Croneis.
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California Highways and Public Works, October, 1930.

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Report of the State Water Commission, 1914.
Tables of discharge for improved Venturi flumes. (Now known as Parshall measuring flumes.)
Rules and regulations.
Water Commission Act, 1929.
Causes Leading to the Failure of the St. Francis Dam.
Report dealing with Water Problems of the State, 1929.
Part III, report of the Division of Engineering and Irrigation, 1922.
Report of the Division of Engineering and Irrigation, 1924.
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Biennial report, 1928.
Biennial report of the Division of Water Rights, 1926.
Bulletin Nos. 5, 6, 7. San Gabriel Investigations.
Bulletin No. 7. Use of Water from Kings River, California.
Bulletin No. 9. Water Resources of Kern River and Adjacent Streams and Their Utilization.
Bulletin No. 22. Vols. I and II—Salt Water Barrier.

Illinois State Geological Survey:

Bulletin 33. Research Needs of Illinois' Coal Industry.
Report of Investigation No. 21. A Group of Laviform Crinoids from Lower Pennsylvania Strata of the Eastern Interior Basin. By J. M. Weller.

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Bulletin 15 and 16. The Geology of Cloud and Republic Counties, Kansas.
The Geology of Mitchell and Osborne Counties, Kansas.

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Directory of Kentucky Mineral Operators. By W. B. Burroughs.
Devonian Rocks of Kentucky. By T. E. Savage.
The Legrande Oil Pool. By W. R. Jillson.

Michigan Geological Survey Division:

Preliminary Report on Howell Structure, Livingston County, Michigan. By R. B. Newcombe.

New Mexico State Bureau of Mines and Mineral Resources:

Circular No. 1 (Revised). An Outline of the Mineral Resources of New Mexico. By E. H. Wells.

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Fourth Series, Bulletin 34. Analyses of the Coals of Ohio. By J. A. Bownocker and E. S. Dean.

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No. 168. Geology and Mineral Resources of the Lancaster Quadrangle, Pennsylvania. By A. I. Jonas and G. W. Stose.

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No. 21. Geology and Water Resources in Parts of the Peace River and Grande Prarie Districts, Alberta. By R. L. Rutherford.

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The Geology of the Maryport District.

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Vol. XLIX, No. 5.
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Nos. 1 and 2. Records of the Geology and Mineral Resources of East Siberia.

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American Association of Petroleum Geologists:

Vol. 14, No. 10.
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Vol. 14, No. 12.

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American Journal of Science:

Vol. 21, No. 121, Fifth Series, January, 1931.

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Proceedings of the Second Annual Convention.

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Vol. XVIII, No. 17. Report of the President of the Academy for the Year 1929. By C. E. Grunsky.
No. 18. Report of the Director of the Museum and of the Aquarium for the Year 1929. By B. W. Evermann.
Vol. XIX, No. 1. Marine Mollusca of Guadalupe Island, Mexico. By A. M. Strong and G. D. Hanna.
No. 2. Marine Mollusca of the Revillagigedo Islands, Mexico. By A. M. Strong and G. D. Hanna.
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No. 4. Some Rissoid Mollusca from the Gulf of California. By F. Baker, G. D. Hanna and A. M. Strong.
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No. 6. Pliocene Deposits North of Simi Valley, California. By W. P. Woodring.
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Vol. 15, No. 12.

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Mining Directory of Minnesota, 1930. By J. J. Craig.

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No. 37. Heat-flow Meters and Thermal Conductivity Measurements. By F. G. Hechler and E. R. Queer.
No. 38. Nonsinusoidal Voltages and Currents in Polyphase Electrical Circuits and Apparatus. By L. A. Doggett.

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Vol. 43, No. 3.
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Tercera Epoca. Vol. 22, Nos. 2, 3, 4, 5, 6 and 7.

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No. 5. A New Race of Gilded Flicker from Sonora. By A. J. van Rossem.
No. 6. New Species of Mollusks. By F. Baker and V. D. P. Spicer.
No. 7. Notes on Some Species of Epitonium, Subgenus, Nitidiscala, from the West Coast of North America. By A. M. Strong.
No. 8. Two New Subspecies of Birds from Sonora. By A. J. van Rossem.
No. 9. The Races of Auriparus Flaviceps (Sundevall). By A. J. van Rossem.
No. 10. Comment on the Marsh Sparrows of Southern and Lower California with the Description of a New Race. By L. M. Huey.

No. 11. New Sonora Races of Toxostoma and Phengopedius. By A. J. van Rossem.
No. 12. Some Geographic Variations in Piaya Cayana. By A. J. van Rossem.
No. 13. A New Verdin from Central Lower California, Mexico. By L. M. Huey.

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Annual report for the year ending June 30, 1929.

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No. 13. Heat Transfer in Automobile Radiators of the Tubular Type. By F. W. Ditters and L. M. K. Boelter.

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Vol. 19, No. 12. Rodents and Lagomorphs from the Later Tertiary of Fish Lake Valley, Nevada. By E. R. Hall.
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No. 14. A New Genus of Bat from the Later Tertiary of Nevada. By E. R. Hall.
No. 15. The Geology of the Potrero Hills and Vacaville Region, Solano County, California. By T. I. Bailey.
No. 16. A Pliocene Mastodon Skull from California, Pliomastodon Vexillarius, N. Sp. By W. D. Matthew.
No. 17. Equidae from the Pliocene of Texas. By W. D. Matthew and R. A. Stirton.

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Waseda University, Tokyo, Japan:

No. 7. Memoirs of the Faculty of Science and Engineering.

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Vol. 35, No. 5.
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Bibliography of Organic Sulphur Compounds. By Borgstrom, Bost and Brown.
Metals and Alloys, Vol. 1, No. 16.
The Physiography of the U. S.
Who's Who in Government.
Neue optische Daten wenig bekannter Minerale. Von T. Barth und H. Berman.
Standards and Specifications for Nonmetallic Minerals and Their Products, 1930. By U. S. Department of Commerce.
Petroleum Development and Technology. Transactions of the A. I. M. E. 1930.
Institute of Metals Division. Transactions of the A. I. M. E. 1930.
Milling Methods. Transactions of the A. I. M. E. 1930.
Reminiscences of a Pioneer. By Colonel Wm. Thompson.

John Hays Hammond Public Mining Library:

The Commercial Technical Dictionary, Spanish-English, English-Spanish.

International Control of Raw Materials. By B. B. Wallace and L. R. Edminster.
Mining Methods. By C. A. Mitke.
Mineralogy. By Miers.
Elements of Optical Mineralogy. By Winchell and Winchell.
The Quantitative Analysis of Inorganic Materials. By N. Hackney.

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Leonards Quadrangle, Kern County.
Miramonte Quadrangle, Kern County.
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Saugus Quadrangle, Los Angeles County.
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Vejor Quadrangle, Los Angeles County.
Dume Point Quadrangle, Los Angeles County.
Russell Valley Quadrangle, Los Angeles County.

Current Magazines on File.

For the convenience of persons wishing to consult the technical magazines in the reading room, a list of those on file is appended:

American Petroleum Institute Bulletin, New York City.
Architect and Engineer, San Francisco.
Asbestos, Philadelphia, Pennsylvania.
Asbestology, Canadian Asbestos Co., Montreal, Canada.
Brick and Clay Record, Chicago.
California Safety News, San Francisco.
Canadian Mining Journal, Gardenvale, Quebec.
Caterpillar, San Leandro, California.
Chemical and Metallurgical Engineering, New York City.
Chemical Engineering and Mining Review, Melbourne, Australia.
Commerce Reports, Washington, D. C.
Commonwealth, San Francisco.
Colorado School of Mines, Golden, Colorado.
Cooper-Bessemer Monthly, Grove City, Pennsylvania.
Engineering and Mining Journal, New York City.
Explosive Service Bulletins, Washington, Delaware.
Fuel Oil, Chicago, Illinois.
Fusion Facts, Whittier, California.
Graphite, Jersey City.
Grizzly Bear, Los Angeles.
Hercules Mixer, Wilmington, Delaware.
Independent Monthly, Tulsa, Oklahoma.
Industrial Employment Information Bulletin, Washington, D. C.
Lubrication, The Texas Co., New York City.
Mining Congress Journal, Washington, D. C.
Mining Journal, London.
Mining Journal, Phoenix, Arizona.
Mining and Metallurgy, New York City.
Mining Review, Salt Lake City.
Mining Truth, Spokane, Washington.
Monthly Review of Business Conditions, San Francisco.
National Sand and Gravel, Washington, D. C.
Oil Bulletin, Los Angeles.
Oil Field Engineering, Philadelphia, Pennsylvania.
Oil and Gas Journal, Tulsa, Oklahoma.
Oil, Paint and Drug Reporter, New York City.
Oil Weekly, Houston, Texas.
Pit and Quarry, Chicago.

Pacific Purchaser, San Francisco.
Petroleum Times, London, E. C. 2.
Petroleum Age, Chicago.
Petroleum World, Los Angeles.
Queensland Government Mining Journal, Brisbane, Australia.
Record, Associated Oil Co., San Francisco.
Rocks and Minerals, Peekskill, New York.
Rock Products, Chicago.
Scientific American, New York City.
Southwest Builder and Contractor, Los Angeles.
Standard Oil Bulletin, San Francisco.
Stone, New York City.
Through the Ages, Baltimore.
Union Oil Bulletin, Los Angeles.

Newspapers.

The following papers are received and kept on file in the library.

Amador Dispatch, Jackson, California.
Barstow Printer, Barstow, California.
Beaumont Gazette, Beaumont, California.
Bridgeport Chronicle-Union, Bridgeport, California.
California Oil World, Los Angeles, California.
Calaveras Californian, Angels Camp, California.
Calaveras Prospect, San Andreas, California.
Colusa Daily Sun, Colusa, California.
Daily Commercial News, San Francisco, California.
Daily Midway Driller, Taft, California.
Del Norte Triplicate, Crescent City, California.
Denver Mining Record, Denver, Colorado.
Exeter Sun, Exeter, California.
Goldfield News, Goldfield, Nevada.
Inyo Independent, Independence, California.
Inyo Register, Bishop, California.
Ione Valley Echo, Ione, California.
Kettleman Oil and Gas News, Kettleman City, California.
Las Vegas Age, Las Vegas, Nevada.
Livermore Herald, Livermore, California.
Mariposa Gazette, Mariposa, California.
Mercury Register, Oroville, California.
Mojave Miner, Kingman, Arizona.
Mojave-Randsburg Record, Mojave, California.
Morning Union, Grass Valley, California.
Mountain Messenger, Downieville, California.
National Industrial Review, San Francisco, California.
Needles Nugget, Needles, California.
Nevada City Nugget, Nevada City, California.
Nevada Mining Press, Reno, Nevada.
Oil Refinery News, Bayonne, New Jersey.
Petroleum Press, Taft, California.
Placer Herald, Auburn, California.
Plumas Independent, Quincy, California.
San Diego News, San Diego, California.
Shasta Courier, Redding, California.
Siskiyou News, Yreka, California.
Sotoyome Scimitar, Healdsburg, California.
Stockton Record, Stockton, California.
Tehachapi News, Tehachapi, California.
Tuolumne Prospector, Tuolumne, California.
Ventura County News, Ventura, California.
Waterford News, Waterford, California.
Weekly Trinity Journal, Weaverville, California.
Western Mineral Survey, Salt Lake City, Utah.
Western Sentinel, Etna Mills, California.

PRODUCERS AND CONSUMERS

The producer and consumer of mineral products are mutually dependent upon each other for their prosperity, and one of the most direct aids rendered by the Bureau to the mining industry in the past has been that of bringing producers and consumers into direct touch with each other.

This work has been carried on largely by correspondence, supplemented by personal consultation. Lists of buyers of all the commercial minerals produced in California have been made available to producers upon request, and likewise the owners of undeveloped deposits of various minerals, and producers of them, have been made known to those looking for raw mineral products.

When the publication of MINING IN CALIFORNIA was on a monthly basis, current inquiries from buyers and sellers were summarized and lists of mineral products or deposits 'wanted' or 'for sale' included in each issue.

It is important that inquiries of this nature reach the mining public as soon as possible and in order to avoid the delay incident to the present quarterly publication of MINING IN CALIFORNIA, these lists are now issued monthly in the form of a mimeographed sheet under the title of 'Commercial Mineral Notes,' and sent to those on the mailing list for MINING IN CALIFORNIA.

EMPLOYMENT SERVICE

Following the establishment of the Mining Division branch offices in 1919, a free technical employment service was offered as a mutual aid to mine operators and technical men for the general benefit of the mineral industry.

Briefly summarized, men desiring positions are registered, the cards containing an outline of the applicant's qualifications, position wanted, salary desired, etc., and as notices of 'positions open' are received, the names and addresses of all applicants deemed qualified are sent to the prospective employer for direct negotiations.

Telephone and telegraphic communications are also given immediate attention.

Technical men, or those qualified for supervisory positions, and vacancies of like nature only, are registered, as no attempt will be made to supply common mine and mill labor.

Registration cards for the use of both prospective employers and employees may be obtained upon request, and a cordial invitation is extended to the industry to make free use of the facilities afforded. Parties interested should communicate direct with our San Francisco office.

PUBLICATIONS OF THE DIVISION OF MINES

During the past fifty years, in carrying out the provisions of the organic act creating the former California State Mining Bureau, there have been published many reports, bulletins and maps which go to make up a library of detailed information on the mineral industry of the state, a large part of which could not be duplicated from any other source.

One feature that has added to the popularity of the publications is that many of them have been distributed without cost to the public, and even the more elaborate ones have been sold at a price which barely covers the cost of printing.

Owing to the fact that funds for the advancing of the work of this department have often been limited, many of the reports and bulletins mentioned were printed in limited editions which are now entirely exhausted.

Copies of such publications are available, however, in the office of the Division of Mines, in the Ferry Building, San Francisco; Bankers Building, Los Angeles; State Office Building, Sacramento; Redding; Santa Barbara; Santa Paula; Coalinga; Taft; Bakersfield. They may also be found in many public, private and technical libraries in California and other states, and foreign countries.

A catalog of all publications from 1880 to 1917, giving a synopsis of their contents, is issued as Bulletin No. 77.

Publications in stock may be obtained by addressing any of the above offices and enclosing the requisite amount in the case of publications that have a list price. Only coin, stamps or money orders should be sent, and it will be appreciated if remittance is made in this manner rather than by personal check.

The prices noted include delivery charges to all parts of the United States. Money orders should be made payable to the Division of Mines.

NOTE.—The Division of Mines frequently receives requests for some of the early reports and bulletins now out of print, and it will be appreciated if parties having such publications and wishing to dispose of them will advise this office.

REPORTS

Asterisks (**) indicate the publication is out of print.

	Price
**First Annual Report of the State Mineralogist, 1880, 43 pp. Henry G. Hanks	----
**Second Annual Report of the State Mineralogist, 1882, 514 pp., 4 illustrations, 1 map. Henry G. Hanks	----
**Third Annual Report of the State Mineralogist, 1883, 111 pp., 21 illustrations. Henry G. Hanks	----
**Fourth Annual Report of the State Mineralogist, 1884, 410 pp., 7 illustrations. Henry G. Hanks	----
**Fifth Annual Report of the State Mineralogist, 1885, 234 pp., 15 illustrations, 1 geological map. Henry G. Hanks	----
**Sixth Annual Report of the State Mineralogist, Part I, 1886, 145 pp., 3 illustrations, 1 map. Henry G. Hanks	----
**Part II, 1887, 222 pp., 36 illustrations. William Irelan, Jr.	----
**Seventh Annual Report of the State Mineralogist, 1887, 315 pp. William Irelan, Jr.	----
**Eighth Annual Report of the State Mineralogist, 1888, 948 pp., 122 illustrations. William Irelan, Jr.	----
**Ninth Annual Report of the State Mineralogist, 1889, 352 pp., 57 illustrations, 2 maps. William Irelan, Jr.	----

REPORTS—Continued

Asterisks (**) indicate the publication is out of print.

	Price
**Tenth Annual Report of the State Mineralogist, 1890, 983 pp., 179 illustrations, 10 maps. William Irelan, Jr.	----
Eleventh Report (First Biennial) of the State Mineralogist, for the two years ending September 15, 1892, 612 pp., 73 illustrations, 4 maps. William Irelan, Jr.	$1.00
**Twelfth Report (Second Biennial) of the State Mineralogist, for the two years ending September 15, 1894, 541 pp., 101 illustrations, 5 maps. J. J. Crawford	----
**Thirteenth Report (Third Biennial) of the State Mineralogist, for the two years ending September 15, 1896, 726 pp., 93 illustrations, 1 map. J. J. Crawford	----
Chapters of the State Mineralogist's Report, Biennial Period, 1913–1914, Fletcher Hamilton:	
**Mines and Mineral Resources, Amador, Calaveras and Tuolumne Counties, 172 pp., paper	----
Mines and Mineral Resources, Colusa, Glenn, Lake, Marin, Napa, Solano, Sonoma and Yolo Counties, 208 pp., paper	.50
**Mines and Mineral Resources, Del Norte, Humboldt and Mendocino Counties, 59 pp., paper	----
**Mines and Mineral Resources, Fresno, Kern, Kings, Madera, Mariposa, Merced, San Joaquin and Stanislaus Counties, 220 pp., paper	----
**Mines and Mineral Resources of Imperial and San Diego Counties, 113 pp., paper	----
**Mines and Mineral Resources, Shasta, Siskiyou and Trinity Counties, 180 pp., paper	----
**Fourteenth Report of the State Mineralogist, for the Biennial Period 1913–1914, Fletcher Hamilton, 1915: A General Report on the Mines and Mineral Resources of Amador, Calaveras, Tuolumne, Colusa, Glenn, Lake, Marin, Napa, Solano, Sonoma, Yolo, Del Norte, Humboldt, Mendocino, Fresno, Kern, Kings, Madera, Mariposa, Merced, San Joaquin, Stanislaus, San Diego, Imperial, Shasta, Siskiyou and Trinity Counties, 974 pp., 275 illustrations, cloth	----
Chapters of the State Mineralogist's Report, Biennial Period, 1915–1916. Fletcher Hamilton:	
**Mines and Mineral Resources, Alpine, Inyo and Mono Counties, 176 pp., paper	----
Mines and Mineral Resources, Butte, Lassen, Modoc, Sutter and Tehama Counties, 91 pp., paper	.50
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**Mines and Mineral Resources, San Bernardino and Tulare Counties, 186 pp., paper	----
**Fifteenth Report of the State Mineralogist, for the Biennial Period 1915–1916, Fletcher Hamilton, 1917: A General Report on the Mines and Mineral Resources of Alpine, Inyo, Mono, Butte, Lassen, Modoc, Sutter, Tehama, Placer, Sacramento, Yuba, Los Angeles, Orange, Riverside, San Benito, San Luis Obispo, Santa Barbara, Ventura, San Bernardino and Tulare Counties, 990 pp., 413 illustrations, cloth	----
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Seventeenth Report of the State Mineralogist, 1920, 'Mining in California during 1920,' Fletcher Hamilton; 562 pp., 71 illustrations, cloth	1.75
Eighteenth Report of the State Mineralogist, 1922, 'Mining in California,' Fletcher Hamilton. Chapters published monthly beginning with January, 1922:	
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Chapters of Nineteenth Report of the State Mineralogist, 'Mining in California,' Fletcher Hamilton and Lloyd L. Root. January, February, March, September, 1923	Free
Chapters of Twentieth Report of the State Mineralogist, 'Mining in California,' Lloyd L. Root. Published quarterly. January, April, **July, October, 1924, per copy	.25

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July, 1925, Mines and Mineral Resources of Del Norte, Humboldt and San Diego Counties	.25
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October, 1926, Mines and Mineral Resources of El Dorado and Inyo Counties, also report on Minaret District, Madera County	.25
Chapters of Twenty-third Report of the State Mineralogist, 'Mining in California,' Lloyd L. Root. Published quarterly:	
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MISCELLANEOUS PUBLICATIONS

**First Annual Catalogue of the State Museum of California, being the collection made by the State Mining Bureau during the year ending April 16, 1881. 350 pp.	----
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**Catalogue of the State Museum of California, Volume II, being the collection made by the State Mining Bureau from April 16, 1881, to May 5, 1884. 220 pp.	----
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**Catalogue of the State Museum of California, Volume IV, being the collection made by the State Mining Bureau from March 30, 1887, to August 20, 1890. 261 pp.	----
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**Catalogue of West North American and Many Foreign Shells with Their Geographical Ranges, by J. G. Cooper. Printed for the State Mining Bureau, April, 1894	----
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OTHER MAPS

**Map of California, Showing Mineral Deposits (50 x 60 in.)	----
**Map of Forest Reserves in California	----
**Mineral and Relief Map of California	----
**Map of El Dorado County, Showing Boundaries, National Forests	----
**Map of Madera County, Showing Boundaries, National Forests	----
**Map of Placer County, Showing Boundaries, National Forests	----
**Map of Shasta County, Showing Boundaries, National Forests	----
**Map of Sierra County, Showing Boundaries, National Forests	----
**Map of Siskiyou County, Showing Boundaries, National Forests	----
**Map of Tuolumne County, Showing Boundaries, National Forests	----
**Map of Mother Lode Region	----
**Map of Desert Region of Southern California	----
Map of Minaret District, Madera County	20
Map of Copper Deposits in California	.05
**Map of Calaveras County	----
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**Map of Trinity County	----
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Topographic Map of Sierra Nevada Gold Belt, showing distribution of auriferous gravels, accompanying Bulletin No. 92 (also sold singly) In 4 colors	.50

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Map No. 39—West Coyote, Los Angeles and Orange counties	.75
Map No. 40—Elwood, Santa Barbara County	.75
Map No. 41—Potrero, Los Angeles County	.75
Map No. 42—Playa Del Rey, Los Angeles County	.75

DETERMINATION OF MINERAL SAMPLES

Samples (limited to three at one time) of any mineral found in the state may be sent to the Division of Mines for identification, and the same will be classified free of charge. No samples will be determined if received from points outside the state. It must be understood that no assays, or quantitative determinations will be made. Samples should be in lump form if possible, and marked plainly with name of sender on outside of package, etc. No samples will be received unless delivery charges are prepaid. A letter should accompany sample, giving locality where mineral was found and the nature of the information desired.

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STATE OF CALIFORNIA
DEPARTMENT OF NATURAL RESOURCES

DIVISION OF MINES

CORDIALLY INVITES YOU TO VISIT ITS VARIOUS DEPARTMENTS MAINTAINED FOR THE PURPOSE OF FURTHERING THE DEVELOPMENT OF THE

MINERAL RESOURCES OF CALIFORNIA

At the service of the public are the scientific reference library and reading room, the general information bureau, the laboratory for the free determination of mineral samples found in the state, and the largest museum of mineral specimens on the Pacific Coast. The time and attention of the State Mineralogist, as well as that of his technical staff, are also at your disposal.

Office hours: 9 a.m. to 5 p.m. daily.
Saturday, 9 a.m. to 12 m.

WALTER W. BRADLEY,
State Mineralogist.

Third floor, Ferry Building, San Francisco, Cal. Branch Offices: Bankers Building, Los Angeles; State Office Building, Sacramento; Chamber of Commerce, Redding; Bank of Italy Building, Bakersfield; San Marcos Building, Santa Barbara; Taft, Coalinga and Santa Paula.

Mining in California

PUBLISHED QUARTERLY

STATE OF CALIFORNIA
DEPARTMENT OF NATURAL RESOURCES
DIVISION OF MINES

FERRY BUILDING
SAN FRANCISCO

DIVISION OF MINES

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STATE OF CALIFORNIA
DEPARTMENT OF NATURAL RESOURCES
DIVISION OF MINES
FERRY BUILDING, SAN FRANCISCO

WALTER W. BRADLEY — State Mineralogist

Vol. 27 — APRIL, 1931 — No. 2

CHAPTER OF

REPORT XXVII OF THE STATE MINERALOGIST

COVERING

ACTIVITIES OF THE DIVISION OF MINES

INCLUDING THE

GEOLOGIC BRANCH

CALIFORNIA STATE PRINTING OFFICE
HARRY HAMMOND, STATE PRINTER
SACRAMENTO, 1931

TABLE OF CONTENTS

	Page
DISTRICT REPORTS OF MINING ENGINEERS	129
Redding Field Division	129
Cyanide Treatment of Gossan	129
Sacramento Field Division	139
San Francisco Field Division	139
Los Angeles Field Division	139
GEOLOGIC BRANCH	140
SPECIAL ARTICLES	141
Stratigraphic Significance of the Kreyenhagen Shale	141
Diatoms and Silicoflagellates	187
Foraminifera of the Kreyenhagen Shale	202
Preliminary Report of the Geology of Santa Cruz Island	214
OIL FIELD DEVELOPMENT OPERATIONS	220
ADMINISTRATIVE	223
MINERALS AND STATISTICS	224
Statistics	224
Museum	231
Laboratory	231
LIBRARY	232
PRODUCERS AND CONSUMERS	244
EMPLOYMENT SERVICE	244
PUBLICATIONS	I

PREFACE

The Division of Mines (formerly State Mining Bureau) is maintained for the purpose of assisting in all possible ways in the development of California's mineral resources.

As one means of offering tangible service to the mining public, the State Mineralogist for many years has issued an annual or a biennial report reviewing in detail the mines and mineral deposits of the various counties.

As a progressive step in advancing the interests of the mineral industry, and as permitting earlier distribution to the public, publication of the Annual Report of the State Mineralogist in the form of monthly chapters was begun in January, 1922, and continued until March, 1923.

Owing to a lack of funds for printing this was changed to a quarterly publication, beginning in September, 1923.

For the same reason, beginning with the January, 1924, issue, it has been necessary to charge a subscription price of $1 per calendar year, payable in advance; single copies, 25 cents apiece. 'Mining in California' is sent without charge to our 'exchange list,' including schools and public libraries, as are also other publications of the Division of Mines.

Pages are numbered consecutively throughout the year and an index to the complete report is included annually in the closing number.

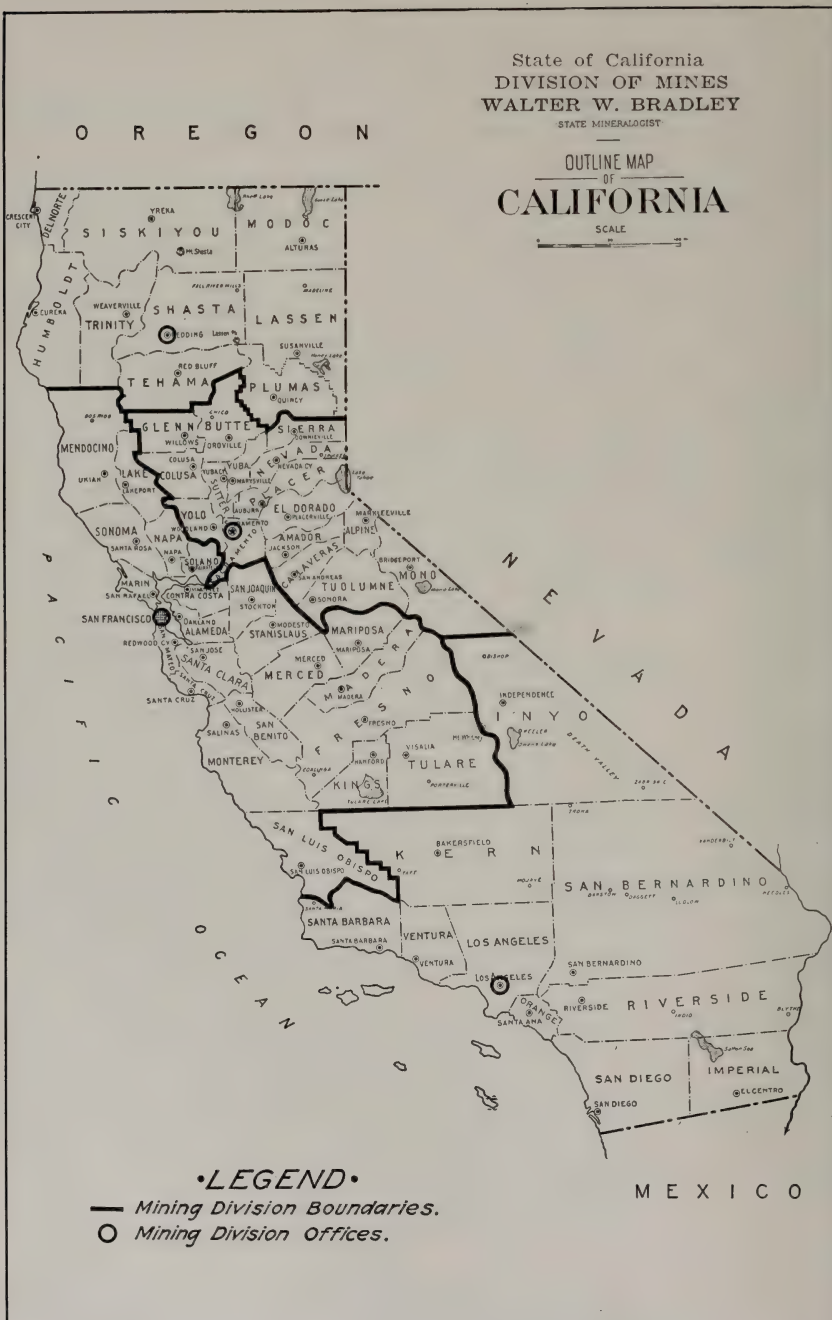
Such a publication admits of several improvements over the former method of procedure. Each issue contains a report of the current development and mining activities of the State, prepared by the district mining engineers. Special articles dealing with various phases of mining and allied subjects by members of the staff and other contributors are included. Mineral production reports formerly issued only as an annual statistical bulletin are published herein as soon as returns from producers are compiled. The executive activities, and those of the laboratory, museum, library, employment service and other features with which the public has had too little acquaintance also are reported.

Beginning with the 1930 issues, the activities and progress of the Geologic Branch are recorded also in these quarterly chapters.

While current activities of all descriptions are covered in these chapters, the practice of issuing from time to time technical reports on special subjects will be continued, as well. A list of such reports now available is appended hereto, and the names of new bulletins will be added in the future as they are completed.

The chapters are subject to revision, correction and improvement. Constructive suggestions from the mining public will be gladly received, and are invited.

The one aim of the Division of Mines is to increase its usefulness and to stimulate the intelligent development of the wonderful, latent resources of the State of California.



State of California
DIVISION OF MINES
WALTER W. BRADLEY
STATE MINERALOGIST
OUTLINE MAP
OF
CALIFORNIA
SCALE
OREGON
NEVADA
MEXICO
PACIFIC OCEAN
SISKIYOU
MODOC
SHASTA
LASSEN
TRINITY
HUMBOLDT
DELNORTE
TEHAMA
PLUMAS
GLENN
BUTTE
SIERRA
MENDOCINO
LAKE
COLUSA
YUBA
NEVADA
PLACER
SUTTER
YOLO
EL DORADO
ALPINE
SONOMA
NAPA
SOLANO
SACRAMENTO
AMADOR
CALAVERAS
MARIN
CONTRA COSTA
SAN JOAQUIN
TUOLUMNE
MONO
SAN FRANCISCO
ALAMEDA
STANISLAUS
MARIPOSA
SAN MATEO
SANTA CLARA
MERCED
MADERA
SANTA CRUZ
SAN BENITO
FRESNO
INYO
MONTEREY
KINGS
TULARE
SAN LUIS OBISPO
KERN
SAN BERNARDINO
SANTA BARBARA
VENTURA
LOS ANGELES
ORANGE
RIVERSIDE
SAN DIEGO
IMPERIAL
•LEGEND•
Mining Division Boundaries.
Mining Division Offices.

DISTRICT REPORTS OF MINING ENGINEERS

In 1919–1920 the Mining Bureau was organized into four main geographical divisions, with the field work delegated to a mining engineer in each district, working out from field offices that were established in Redding, Auburn, San Francisco and Los Angeles, respectively. This move brought the office into closer personal contact with operators, and it has many advantages over former methods of conducting field work. In 1923 the Redding and Auburn field offices were consolidated and moved to Sacramento.

The Redding office was reestablished in 1928, and the boundaries of each district adjusted. The counties now included in each of the four divisions, and the locations of the branch offices, are shown on the accompanying outline map of the State. (Frontispiece.)

Reports of mining activities and development in each division, prepared by the district engineer, will continue to appear under the proper field division heading.

Although the petroleum industry is but little affiliated with other branches of mining, oil and gas are among the most valuable mineral products of California, and a report by the State Oil and Gas Supervisor on the current development and general conditions in the State's oil fields is included under this heading.

New County Reports.

The series of separate reports on the mines and mineral resources of the different counties, that together comprise the State Mineralogist's Reports XVI to XVII, inclusive, in the case of many of the counties have become exhausted. Those still in stock being in need of revision, it was deemed advisable, beginning with the January, 1925, issue of 'Mining in California,' to make the district engineers' reports in the form of a complete general report on the mines and mineral resources in one or more of the counties in each district.

This program has been followed as nearly as possible in succeeding numbers of the quarterly, and the county series completed during 1930. A new series of reports on individual economic minerals, mainly nonmetallics, is now (1931) under way.

REDDING FIELD DIVISION

CHAS. VOLNEY AVERILL, Mining Engineer

The Mountain Copper Company, Ltd., Cyanide Treatment of Gossan

The new cyanide plant of the Mountain Copper Company is very interesting, not only because it is treating a gossan ore, which hitherto has been considered not amenable to this process, but also because the material is being handled at a lower cost than any other gold ore, so far as the writer knows, with the single exception of the Alaska Juneau Mine, Alaska. Roughly the cost of mining and milling is $0.85 per ton in a plant that is handling 550 tons per day.

History.

The property is one of the oldest on the Shasta County copper belt. It was discovered in the early sixties; and the Mountain Copper Co., Ltd., of London, England, purchased it on January 1, 1897. In addition to being at one time among the largest copper producers of the world, the company has produced sulphuric acid, fertilizers, gas purifier and bluestone. A smelter (now dismantled) was operated at Keswick; and there is another at Martinez. In addition to the cyanide plant at Iron Mountain, the company has a flotation plant for siliceous copper ores, and the Hornet mine, a producer of pyrite. For information on the activities other than at the cyanide plant, the reader is referred to State Mineralogist's Report XXII, pp. 142 and 154–160.

The location is in Sec. 34 and 35, T. 33 N., R. 6 W., M.D.M., 17 miles northwest of Redding. A railroad station on the main north-south line of the Southern Pacific at Matheson serves the property. Wm. F. Kett, 112 Market Street, San Francisco, California, is general manager. At the mine, post-office address Matheson, M. J. Murphy is general superintendent and J. M. Basham is mill superintendent. The writer is indebted to these officials for the information on which this article is based.

The ore now being treated is a typical reddish-brown gossan, largely-porous oxides of iron remaining from the leaching by surface waters of a body of iron and copper sulphides. The weight is about 100 pounds per cubic foot. About 0.4% copper remains in it; and there is a small content of mercury, which appears in the precipitates, also a little arsenic. Early reports by metallurgists were to the effect that cyanide consumption would be too great on this material to make its treatment profitable. A batch of samples sent out in 1928, however, brought returns showing good extraction without excessive cyanide consumption. This led to further work on the gossan with detailed tests described below.

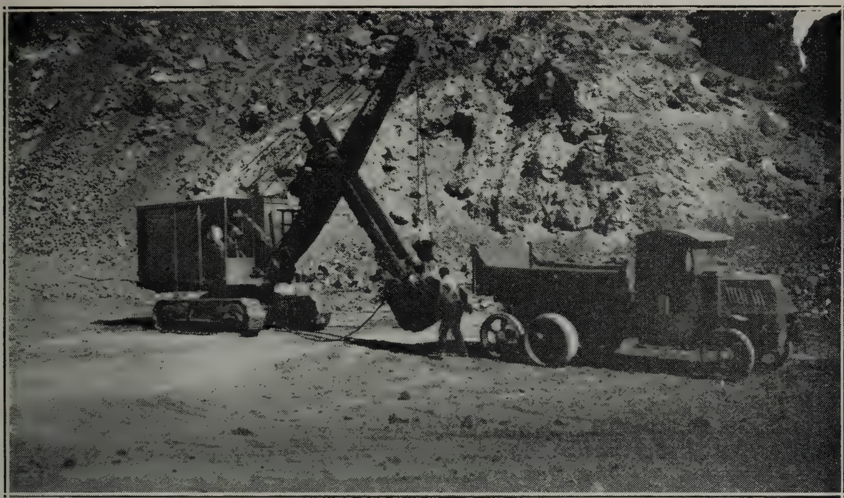
Sampling and Ore Reserves.

Extensive samples taken from 50-ft. squares on the surface gave returns of $2.40 per ton in gold. From diamond-drill holes, the average for the bottom of the gossan, near the top of the copper ore, was found to be $1.60 per ton. For intermediate points, diamond drilling was unsatisfactory, because the soft gossan did not give a core. An average of samples taken on the surface and those at the bottom of the gossan, supplemented by samples taken from underground workings in the gossan, indicated that the deposit would yield 365,000 tons running $2.00 per ton and 190,000 tons running $1.40 to $1.50 per ton, the average for the mass being $1.85 per ton. No gold coarse enough to detect in a pan has ever been found in the gossan.

Preliminary Tests.

A four-ton plant was built; and 17 test runs were made. Gossan was crushed to 2-mesh, the resulting material having 10% to 15% of fines of minus 100-mesh. If this was dumped in a tank in the form of a cone, it was found that the leaching solutions formed channels due to the classification in size that takes place on such a cone, the coarse sizes running out to the edges. This was prevented by moistening

the ore before putting it in a tank, and spreading it in layers one foot thick to a total depth of eight feet. Leaching with a strong solution containing one pound of cyanide per ton continued for two days; and this was followed with a one-day wash with a 0.4-lb. cyanide solution. Fifteen to twenty pounds of lime per ton of ore were used. Weight



Two views of gossan quarry, The Mountain Copper Co., Ltd.

of solution circulated was 1.8 times the weight of ore; and a water wash of 15% of the weight of the ore followed. Extraction was improved by letting all solutions stand for a few hours before circulating. Tailings were discharged at 10% to 15% moisture. Various combinations of cyanide and lime strength were tried; and the economical point was found to be a consumption of 0.34 lb. of cyanide per ton of ore and

7½ lb. of lime. As high as 40 lb. lime per ton of ore were used without producing any protective alkalinity in solutions with phenolphthalein as the indicator. On account of this lack of protective alkalinity, zinc shavings gave poor precipitation; but the present method, using zinc dust, gives excellent results. These tests indicated that on material of a maximum size of 2-mesh, a $0.40 tailing was to be expected. With a head of $1.60, this meant a recovery of 75%; heads $2.00, recovery 80%; and heads $3.00, recovery 87%. In addition to determining the feasibility of cyaniding the gossan, these tests indicated three important details of treatment:

1. No advantage was to be gained by using very large amounts of lime.
2. Moistening the leaching-tank charges and spreading them in layers would reduce channeling.
3. Putting the first solution on from the bottom of the tank would also reduce channeling.

An outside man was then called in to check the tests, which he did, with the exception that he recommended crushing to a maximum of one inch. The original idea was to handle relatively-fine material, which could be sluiced out of the leaching tanks with water. In order to handle the coarser size the plant was designed with conveyor belts to discharge the tailings. However, tests now under way, which will be described below, indicate that extraction can be improved by crushing to the smaller sizes.

Mining.

At present mining is being done in an open quarry with a Bucyrus Erie ¾-cubic yard electric shovel with caterpillar drive. The quarry now has an 85-ft. face; but this will soon be reduced to 50 ft. or less by building an incline of overburden and running the shovel up to a higher bench. Depth of gossan below the floor of the quarry is about 30 feet. Ore is loaded on Mack trucks, which haul 8 tons to a load. The haul is 2200 ft.; and three trucks and three drivers are required. The reason for locating the mill at this distance from the mine was to get space for storage of tailings. The trucks handle enough ore for a day's run of the mill in six hours, leaving two hours out of each shift for handling overburden. Work in the pit is handled by three quarry men and one shovel man. Blasting powder averages 4000 lb. of 20% gelatine per month for 16,000 tons of ore; but this is greater when much overburden is handled.

Crushing.

From the trucks the gossan is dumped onto an inclined grizzly of steel rails. Over-size runs to a horizontal section of the grizzly, where it is broken with sledges to pass the openings, 8 and 9-inch. To hold down these horizontal rails, sections of old ball-mill liners have been bolted over the ends, and have given good service on this section where the large chunks are broken. From the grizzly the gossan drops to a storage bunker 38 by 16 by 20 ft. high with a capacity of 350 tons which can be drawn from the chutes. The bunker discharges through three chutes with horizontal rack-and-pinion gates to a pan

conveyor 42 inches wide by 50 ft. long, set close under the lips of the chutes. The motion of the conveyor, with the chute gates properly set, controls the flow of ore; and the man at the crusher can regulate the feed by starting or stopping the pan conveyor. This discharges onto an inclined grizzly with 2-inch openings; and oversize is crushed in a 10 by 20-inch Buchanan jaw crusher. Ore then goes to 40 by 15-inch Allis Chalmers Anaconda rolls. This completed the equipment in the original installation; but results indicated desirability of finer crushing; and a Link Belt vibrating screen with 20 by 12-inch rolls for screen oversize was added. All of the gossan must pass through the vibrating screen with openings of ½-inch. A crimped wire screen with ½-inch square openings was used at first; but at present a Tyler Tryrod screen is in use. Openings between wires in this are in the form of a slot, ½-inch by about 4 inches. If any trouble is had with moist fines clogging the screen, the feed is stopped for a moment; and the vibration of the wires soon clears it. Screened ore is picked up by the main conveyor-belt, over which a dry-lime feeder is placed. Crusher jaws of manganese steel show no wear from the 135,000 tons that have gone through the plant; and the rolls show very little wear.

Charging Tanks.

Leaching vats are cylindrical wood-stave tanks, 25 ft. 8 in. inside diameter and 12-ft. staves. There are ten of them arranged in units of five each, one unit handled by the day shift, the other by the night shift. For charging, a belt conveyor with tandem drive and automatic tripper runs over the row of tanks. The tripper is run back and forth over the tank to be charged; and a man in the tank spreads the gossan in 18-inch layers. Deflecting chutes from the tripper aid in this spreading. The tanks are filled within 3 inches of the top and the ore settles 6 inches additional as the leaching solution comes on. The strong leaching solution is started in from the bottom of the tank when it is half full of ore. The roof over the conveyor covers about two-thirds of the tank; and for rainy weather canvas curtains are provided to cover the balance and keep the men dry.

Leaching.

Of the five tanks in a unit, one is always being filled with ore, a second is discharging tailings, in a third the ore is being leached with strong solution, in a fourth with weak solution, and in a fifth the tailings are being washed. The following actual treatment report, of which one is made out for each charge, will make this clearer:

THE MOUNTAIN COPPER COMPANY, LTD.—TREATMENT REPORT

	Date	Hour		
Charge No. 609			Strong solution leach to gold sump	185 T.
Tank No. 7			Weak solution leach to strong sump	185 T.
			Barren solution leach to weak sump	190 T.
Tank filled begin	April 3, 1931	6:00 p.m.	Water wash to weak sump	65 T.
Tank filled finish	April 4, 1931	2:15 a.m.	Barren to waste	40 T.

Ft. ore in tank—10½

	Date	Tons	Time		Titrations, pound per ton solution	
			Start	Finish	NaCN start	NaCN finish
Strong solution leach						
Strong solution added	April 4, 1931	75	12:30 a.m.	2:30 a.m.	0.7	0.6
Charge stood	April 4, 1931		2:30 a.m.	7:00 a.m.		
Additional strong solution added	April 4, 1931	110	7:00 a.m.	9:45 p.m.	0.5	0.5
Drained			9:45 p.m.	12:10 a.m.		
Weak solution leach						
Weak solution added	April 5, 1931	55	12:10 a.m.	1:30 a.m.	0.5	0.5
Charge stood						
Additional weak solution added	April 5, 1931	130	1:30 a.m.	5:00 p.m.	0.5	0.5
Drained			5:00 p.m.	9:45 p.m.		
Barren solution leach						
Barren solution added	April 4, 1931	60	9:45 p.m.	11:00 p.m.	0.4	0.4
Charge stood						
Additional barren solution added	April 5, 1931	130	11:00 p.m.	9:45 p.m. (6th)	0.4	0.4
Drained	April 6, 1931		9:45 p.m.	12:10 a.m. (7th)		
Water Wash						
Water added	April 7, 1931	65	12:10 a.m.	5:00 a.m.		
Drained			5:00 a.m.	7:00 a.m.		

	Date	Hour
Tank discharged begin		
Tank discharged finish		

Remarks:

West face quarry
Wet tails.

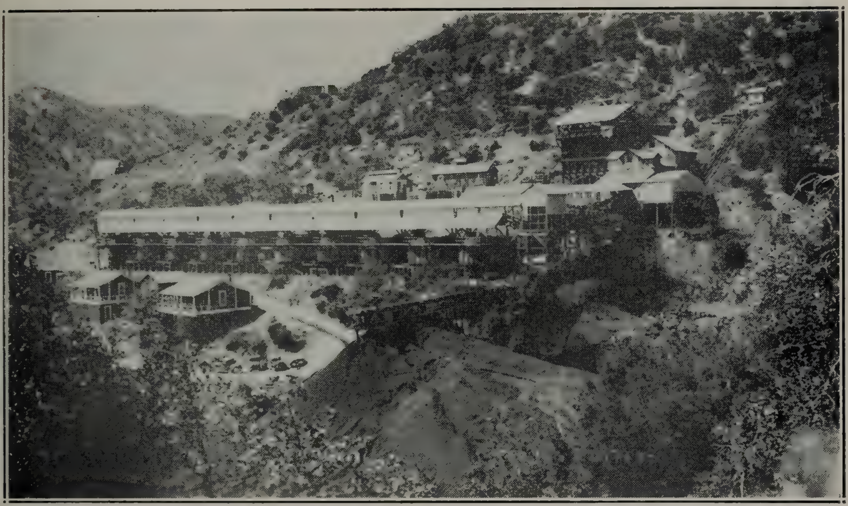
(The original blank provides columns for CaO titrations but no alkalinity is shown, so these are here omitted).

Filter bottoms of the leaching tanks consist of cocoanut matting covered with 10-ounce canvas and 2 by 2-inch cleats, six inches apart. These bottoms are washed and cleaned once every six weeks by hosing with water. The first strong solution is put on the charge from the bottom of the tank; all others from the top. Each unit of five leaching tanks is supplied with three sump-tanks 8 ft. in diameter by 6 ft. high; and each of these is equipped with a 2-inch Krogh pump. The four main solution-tanks, strong, weak, gold, and barren, are 25 ft. 8 inches in diameter by 12 ft. high; and are set on higher ground than the leaching vats. The gold solution tank has a filter bottom covered with two feet of coarse sand. No trouble has yet been experienced from cloudy or dirty solutions even from the leaching tanks. Main solution lines are of 2½ and 3-inch pipes. Strong solution is kept below one

pound of cyanide per ton to avoid dissolving the copper in the gossan. If allowed to dissolve, this copper is troublesome during the melt, getting into the slag and bullion.

Discharging Tailings.

Four holes, 16 inches square, spaced between the sides of the tank and the center are provided for discharging tailings. Two conveyor



Two views of cyanide plant, The Mountain Copper Co., Ltd., Shasta County.

belts run under these, discharging to a cross-belt, which stacks the tailings. Water is used at this stack to spread the tailings in the impounding basins. The 16-inch holes are too large when the tank is full of tailings; and if the full opening is used the conveyor belt is likely to be overloaded. Hence each hole is provided with a false cover

in which a slot has been cut; and these are placed over the holes from inside the tank before filling. Tailings are first worked through the slot from below; then when the inverted cones come together at the top, the men yank out the false covers with a hook, and work from the inside of the tank. Four safety ropes hang in the tank for protection during this part of the operation. Three men discharge a 276-ton tank and clean the bottom ready for the next charge in an 8-hour shift.

Precipitating.

The latest standard Merrill-Crowe vacuum process is used to precipitate the gold from solution. A vacuum pump working on a steel tank de-aerates the solution before precipitation. Instead of a filter press, small canvas filter-leaves, 3 by 4 ft., submerged in a small tank with an agitator of the propeller type in the bottom, are used. Zinc dust is fed to this tank; and precipitation takes place in it. At time of cleanup, the contents of the tank and washings from the filter leaves are transferred to a second small tank with a filter bottom, where as much moisture as possible is removed from the precipitates with the vacuum pump. Two 2-inch centrifugal pumps circulate the solutions in this department. After a cleanup precipitation is started again by feeding 10 lb. of zinc dust immediately, then $\frac{3}{4}$-lb. per hour for 30 hours; then 12 lb. per day are fed. The ore contains mercury, which goes into the precipitates to the extent of 8 to 10% of their weight, and which is believed to aid precipitation. Barren solution from this process never assays more than a trace of gold.

Melting Precipitate.

Dried precipitate is melted in a No. 150-crucible tilting furnace, burning distillate, with the following flux to each 100 lb. of precipitate: 24 lb. sodium carboniate, 32 lb. sand, 40 lb. borax, 9 lb. manganese dioxide. Bullion is first poured into a conical mold; and is then remelted in the same crucible for pouring the brick of 1000 ounces. The fineness of the bullion averages about 460 parts per 1000 in gold and 185 in silver.

Slag from the melt is ground in a 24 by 24-inch ball mill, and fed to a Deister concentrating table, from which three products are taken. Middlings are reground; and the fines are put over a "mat-o-gold" rocker. This treatment results in the recovery of $125 in gold shot per cleanup. Slag tailings, assaying $130 per ton, are shipped to the smelter.

Detailed Figures for March, 1931.

Tons ore treated	16,847
Tons ore crushed	16,834
Crushing hours	432.25
Tons crushed per hour	38.95
Average tons treated per day	543.4
Average heads, gold	$1.654
Average tails	.452
Indicated extraction	72.8%
Tons solution precipitated	11,060
Value precipitated	$21,689.71
Pounds lime per ton	8.35
Pounds cyanide per ton (Aero Brand black cyanide)	.344
Pounds zinc dust per ton of ore	.0257

Present Tests.

While the plant is returning a very satisfactory profit at present, the operators consider it still in the experimental stage, and are conducting tests to improve the process. A change that will probably be made shortly is to reduce the size of the openings in the screen in the crushing department. That the greater part of the loss in the tailings is in the larger sizes is indicated in the following tests:

Two samples, A and A_1, of the same gossan from a mill tank were given parallel treatment in one test. Sample A was 29.3% coarser than 4-mesh. In sample A_1 the oversize was broken to pass the 4-mesh screen. With parallel treatment in the testing plant, A gave a 35¢ tailing, and A_1 a 20¢ tailing.

The following screen test of mill tailings indicates the same thing:

Size	*Per cent*	*Gold*	*Product (col. 1 x col. 2) cents*
plus 2	7.2	1.20	8.64
plus 4 minus 2	27.1	.60	16.26
plus 10 minus 4	20.2	.40	8.08
plus 20 minus 10	13.4	.40	5.36
plus 40 minus 20	9.7	.20	1.94
plus 60 minus 40	5.7	.20	1.14
plus 80 minus 60	2.3	.30	.69
plus 100 minus 80	1.2	.30	1.23
plus 150 minus 100	2.9		
minus 150	10.3	.60	6.18
			49.52

$$\frac{49.52}{100} = \$0.495 \text{ assay value (calculated) unwashed tails.}$$

Heads, $2.00. Indicated extraction, 75.2%.

Power.

In treating 16,847 tons in March, 1931, the mill used 69,828 horsepower hours, and the quarry 8500. Power of individual motors in the plant follows:

	Number	*hp.*
Pan conveyor	1	5
Buchanan crusher, large rolls and feeder (No. 2 conveyor)	1	75
No. 3 conveyor	1	5
Small rolls and No. 3A conveyor	1	15
No. 4 or tripper conveyor	1	10
No. 5 and 6, tailings discharge conveyors	1	20
No. 7 conveyor, on which No. 5 and 6 discharge	1	5
Solution pumps	6	3
Precipitating department pumps	2	3
Agitator and zinc feeder	1	3
Vacuum pump	1	2
Dissolving cyanide	1	½
Refinery	1	2

Chemicals.

A white sodium cyanide was used at first; but recently Aero brand has been used; and results are just as good with a cost of ¾¢ per pound less for available cyanide. It is dissolved in an agitator made from an old air receiver, in which a filter bottom has been placed. Paddles in this are turned at about 10 revolutions per minute by a ½-hp. motor

and speed reducing unit. Cyanide solution must be aerated to avoid the formation of soluble sulphides in the precipitate.

Lime used is 86% CaO or 97% $CaCO_3$ equivalent, and costs $12 per ton at Matheson or about $14 at the mine. Tests have shown that no particular advantage is gained by using more than 7½ lb. of lime per ton of ore.

Lead acetate is added to the gold solution tank at the rate of one pound per shift. Chemicals used for flux have been mentioned under 'Melting Precipitate.' Water is brought in by gravity during the winter; but in the summer must be pumped from the creek below against a head of 1300 feet.

Costs.

The original plant consisting of crushing equipment and one unit of five leaching tanks cost $48,000. Recent additions to double the capacity and put the plant in its present condition cost $27,000, and quarry equipment about $25,000, bringing the total to $100,000. The average per ton costs for March, 1931, which are fairly representative, were as follows:

Quarry	
Per ton delivered	$0.385
Tons 16,834	
Cyanide plant	
Labor	.182
Material	.176
Power	.031
Local general expense	.024
Local administration	.015
Express on bullion, etc.	.004
Total per ton	$0.817

No general administration expenses or depreciation on plant are included in above figures. Trucks are charged out at the rate of $3 per hour including driver, and the shovel at 8¢ per ton. This charge on the shovel will cover complete depreciation in five years.

Wages vary from $4.00 for laborers to $5.75 for shovelmen; and the crew consists of the following:

Three truckmen, 1 shovel man, 3 quarry men, 2 mechanics, 2 grizzly men, 2 crusher men, 2 tripper men, 2 tank men, 6 tank unloaders, 1 assayer, 1 assayer's helper, 3 solution men, 1 electrician, 1 man on tailings, 1 roustabout—31.

SACRAMENTO FIELD DIVISION

C. A. Logan, Mining Engineer

Mr. C. A. Logan, District Mining Engineer, is engaged in preparing a special 'Mother Lode' report, and there is no county report in this issue.

SAN FRANCISCO FIELD DIVISION

C. McK. Laizure, Mining Engineer

There is no report from the San Francisco Field Division, as the present series of county reports is complete for this district.

LOS ANGELES FIELD DIVISION

W. Burling Tucker, Mining Engineer

The present series of county reports is now complete for this district. A special report upon feldspar and silica is being prepared by Mr. W. B. Tucker, District Mining Engineer, and Mr. Reid J. Sampson, Assistant District Engineer.

GEOLOGIC BRANCH

PUBLICATION OF PAPERS ON THE GEOLOGY OF CALIFORNIA

Olaf P. Jenkins, Chief Geologist

In this issue of Mining in California, the April, 1930, chapter of the twenty-seventh annual report of the State Mineralogist, four papers covering special branches of geological study appear. They are listed as follows:

(1) Stratigraphic significance of the Kreyenhagen shale of California. By Olaf P. Jenkins.

(2) Diatoms and silicoflagellates of the Kreyenhagen shale. By G. Dallas Hanna.

(3) Foraminifera of the Kreyenhagen shale. By C. C. Church.

(4) Preliminary report of the geology of Santa Cruz Island, Santa Barbara County, California. By William W. Rand.

It will be noted that three of these papers deal with one special subject, *i.e., the Kreyenhagen shale* of California. From the standpoint of oil geology and the oil industry these articles should be of special interest because the formation which is under discussion is considered by most geologists familiar with the subject to be one of the most important sources of oil of the Coalinga district and Kettleman Hills.

The Geologic Branch of the Division of Mines is greatly indebted to Mr. Rand and to the Department of Geology, University of California, for his generous contribution on the geology of Santa Cruz Island.

The Geologic Branch of the California State Division of Mines expects to continue to publish in the future technical articles on the geology of California.

STRATIGRAPHIC SIGNIFICANCE OF THE KREYENHAGEN SHALE OF CALIFORNIA

By Olaf P. Jenkins*

ABSTRACT

The Kreyenhagen shale is assumed to be an important probable source of oil of the Temblor sandstone. A dual type locality was originally given for the Kreyenhagen shale. The name was applied to shales on Reef Ridge, south of Coalinga, lying between the Avenal and Temblor sandstones, whereas the originally collected foraminifera, employed to determine the age of the Kreyenhagen, came from shales north of Coalinga, beneath the Domengine sandstone. The Federal Survey, however, in the area north of Coalinga, mapped as Kreyenhagen, the series of the diatomaceous strata lying above the 'Tejon' (Domengine) and below the 'Vaqueros' (Temblor). In this series are now found two unconformities which divide it into three distinct units and account for previous conflicts in stratigraphic correlation. It is inferred by the writer that these units may be correlated with their sandstone equivalents outcropping in the south end of the Valley. Accordingly, they would be expected to occur in places beneath the Valley floor. The significance of this possibility, as regards oil and gas exploration, is apparent, especially if the units thicken considerably. Previous work, bearing on the Kreyenhagen shale problem, is reviewed and discussed by the writer.

INTRODUCTION

The assumption that the Kreyenhagen shale as here defined is one of the important source rocks of the oil of the Temblor horizon in the San Joaquin Valley, especially in the region about Coalinga, has been made by most geologists who have studied the problem (19, 35 and many other references†). Its organic content, its petroliferous character in many places, and the fact that it underlies producing oil sands are indications that it has supplied oil to many wells, especially those of the 'Vaqueros' or Temblor horizon (the Miocene sands that overlie the Kreyenhagen shale unconformably).

The stratigraphic problem of the Kreyenhagen shale is bound up in a history of controversies, which, if carefully analyzed, are found largely to be the result of misunderstandings concerning the work of different geologists. The subject has recently received much attention and discussion, and as a result, the geologists at work on the problem have a much better understanding of it, while many others who have listened to the discussions are still more confused as to the status of the problem. It is the purpose of this paper to clarify the conceptions and to indicate both the stratigraphic and economic significance of the problem.

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† See Bibliography, page 149.

The reader is referred, by means of numbers enclosed in parentheses, to the accompanying 'Bibliography on the Kreyenhagen shale problem' for the history and details of the entire controversy up to the present date.

The study of the Kreyenhagen shale by various geologists has covered a period of over sixty years. Though its name was given to it in 1905 (5), the definition of the formation, likewise its age, is still in doubt. It has been assigned to various ages, Eocene, Oligocene, Miocene, and even Cretaceous. The question of its age and such arguments as those regarding the validity of the Oligocene as a definite period, are considered by the writer not to be of much value, unless the detail of stratigraphic correlation of the different associated geologic units be clearly understood.

Our attention is brought to bear, therefore, on these particular units which are exposed along the hills bordering the western side of the San Joaquin Valley.

ACKNOWLEDGMENTS

The writer is indebted to the following persons for advice and assistance in the field and in the office: J. P. Smith, Eliot Blackwelder, Robert Anderson, F. M. Anderson, C. M. Wagner, Leo Fox, Downs McClosky, W. E. James, P. D. Goudkoff, F. E. von Estorff, B. L. Clark, G. D. Hanna, C. C. Church, W. P. Woodring, H. G. Schenck, D. D. Condit, W. S. W. Kew, and others. The greater part of the writer's study was carried on in connection with the preparation of his doctor's dissertation, submitted to the Department of Geology, Stanford University, in 1930. The field investigation began with a detailed investigation done under the direction of the Geological Department of the General Petroleum Corporation.

DEFINITION

The name Kreyenhagen, as used in the present discussion, represents certain organic shales (not yet definitely assigned to any one age, though probably Eocene or possibly Oligocene) lying on the hilly western side of the San Joaquin Valley, above known Eocene sandstones and sandy shales (variously called Domengine, Tejon, Meganos, or Martinez?) and separated from the *known* Eocene by no marked unconformity.

The Kreyenhagen is not *known* to be Eocene, but inference is made by the writer that it is probably equivalent to the *type* Tejon, which in turn is definitely of Eocene age.

The writer places the upper boundary of the Kreyenhagen shale at the first unconformity encountered. This shale series is considered by the writer to include more strata north of Coalinga than it does farther to the south on Reef Ridge, on the Kreyenhagen Ranch, where the Kreyenhagen wells are located. The name for the Kreyenhagen formation was taken from this locality by F. M. Anderson (5) who first described this series of rocks. To the north, the uppermost white diatom beds are regarded as an added thickness, which, for the most part, were apparently eroded in the area exposed to the south, prior to Miocene deposition. The added thickness of white diatomite, however, should not include, the writer contends, the so-called Leda zone which lies above it unconformably, and contains a molluscan fauna previously used by some paleontologists to place its age as Oligocene (5, 10, 17, 23,

26, 53, 64). This zone, important stratigraphically, is, however, so thin (maximum 150 feet, occurring on Domengine Ranch and in the region north of Arroyo Ciervo) that it is hardly mappable.

The lower boundary of Kreyenhagen shale proper does not appear to be a distinct unconformity, though in places (as north of Oil City Camp) there is an indication of a break in depositional continuity. The lower contact, however, may be regarded as a disconformity. A number of fossils (foraminifera and mollusca), diagnostic of the Eocene, have been found below this contact (43), though some geologists thought for a time that they came from the Kreyenhagen itself (44). On Reef Ridge, therefore, where no clear-cut exposure of the contact is visible, the writer is inclined to place the lower boundary of the Kreyenhagen above the sandy clay zone (65) in which diagnostic Eocene fossils (foraminifera and mollusca) are found in abundance.

The fauna and flora found in the mapped Kreyenhagen shale north of Coalinga contains abundant micro-organisms which are not distinctly diagnostic as to geologic age. They consist principally of diatoms (37), silicoflagellates (58), and foraminifera (57). South of Coalinga the fossils are poorly preserved. The occurrence of two mud pectens are well known, *Pecten interradiatus,* which occurs in the lowermost beds, ranging within a few hundred feet, vertically, and *Pecten peckhami,* which has been found in abundance in the northern upper white diatomites, but rarely in the upper layers in the region south of Coalinga. Though not at all diagnostic as to age, these pectens follow fairly closely certain definite lithologic and stratigraphic zones. It is interesting to know that *Pecten interradiatus* is generally considered to be an Eocene form, while *Pecten peckhami* is more often found in the Miocene, though like forms of both have a long range, from Cretaceous to the present.

DUAL TYPE LOCALITY

As previously stated, the name Kreyenhagen was first given to the formation by F. M. Anderson (5) on account of its development at the 'Kreyenhagen Wells' on Canoas Creek, Reef Ridge, south of Coalinga. In naming it, he included also the shales north of Coalinga, which he considered correlative and from which he collected fossil foraminifera of distinct Eocene age. In fact, some of the foraminifera are similar to those found on Reef Ridge in muddy shales immediately beneath the siliceous Kreyenhagen shales. Besides, the fossiliferous Eocene beds of the region north of Coalinga, some of the Moreno (Cretaceous) shales of that locality were included. For the reason that two localities were used in the first description, the writer has referred to them as the *dual type locality.*

Later, government geologists published geological reports of the Coalinga district, but did not employ the name Kreyenhagen, though mentioning the fact that F. M. Anderson had previously used it. They included the formation with the Tejon (7, 10, 13, 14).

Still later, the region north of Coalinga was mapped by the Federal Survey, and at this time the name Kreyenhagen was adopted but not in the sense that F. M. Anderson used it in that northern field (19). The name was applied to the diatomite beds (lying above the known Eocene and below the known Miocene) which were correlated with the Canoas Creek shales and referred questionably to the Oligocene.

Although the correlation was for the most part correct, the use of the formation name in this manner brought forth controversy which has never entirely ceased.

The fact that the only fossils actually found in this series of shales have never proved to be satisfactory diagnostic forms, has lent still more reason for inquiry and discussion.

STRATIGRAPHIC UNITS AND SIGNIFICANT UNCONFORMITIES

A search which the writer made for definite contacts between members of the previously mapped Kreyenhagen shale, has resulted in the recognition of very significant unconformities which serve definitely to divide the series into separable formations, thereby clearing the problem of some apparent conflicting evidences.

At least four contacts appear in places to be unconformable. These four may be described as follows:

(1) The contact which bounds the lower limit of the Kreyenhagen shale.

(2) The contact of the Kreyenhagen shale with an overlying sandstone and shale member, occurring in the Cantua-Panoche region.

(3) The contact between the shale phase of this member with the so-called Leda zone.

(4) The contact between the Leda zone and the overlying Temblor formation.

In most places, the Temblor sandstone rests directly on the eroded surface of the Kreyenhagen shale, but in other places intervening strata give testimony that some deposits were made during that lapse in time, represented generally by a break in sedimentation.

The first of these contacts is generally found to be the most poorly exposed. In a few localities, for example, north of Coalinga in the high hill northeast of Oil City Camp, the contact may be exposed by digging into the weathered slope. At the very base of the brown Kreyenhagen shale thin-interbedded layers of greenish sandstone lie upon the weathered or lateritic surface of sandy-clay shales of definite Eocene age. These sandy shales contain an abundance of foraminifera. With few exceptions these microscopic fossils, occurring together with some mollusca, are not found above this well-defined contact. The writer is inclined to believe that the contact represents a disconformity. The contact of these same horizons was not definitely uncovered south of Coalinga. The writer is inclined to believe that it would be found to lie above the sandy clay shales, rich in foraminifera, which have been collected in the so-called 'transitional beds' one mile south of Big Tar Canyon (65). *Pecten interradiatus,* through generally confined to the beds above the contact, occurs also in the beds below the supposed contact of this locality and the exposed contact north of Oil City Camp.

The second contact has been recorded by Condit in the Cantua Creek-Panoche Creek district (64). He recognizes it as an unconformity. It is exposed on a creek north of Arroyo Ciervo where it may doubtless be an unconformity, but one of very peculiar character. Angular fragments of the underlying shale occur in the sandstone above and masses of the sandstone occur in the shale below. If the sandstone did not show distinct evidences of bedding and if it did not contain fossiliferous beds (though the fossils are broken into fragments) the whole

sandstone member might better be classified as an intrusion (61) similar to the many other neighboring sandstone bodies which clearly show this type of origin. As a matter of fact, parts of this sandstone member distinctly intrude the shale beds below as well as the sandstones from which they probably originated. The interstructural relationship of sandstone beds and intrusions is most confusing, indeed.

Above this sandstone member lies a diatomaceous shale (with *Pecten peckhami*) which is similar to the white phase of the Kreyenhagen shale below. For this reason, the intervening sandstone might rightly be regarded as a member of the Kreyenhagen. A few fossils from the sandstone, especially one species (*Thyasira folgeri* Wagner & Sch.), might correlate it (though the evidence is meager) with beds above the Kreyenhagen in the region of Devils Den. Its whole character is totally different from anything else occurring within the Kreyenhagen, with exception of a sandstone (either interformational or intrusive) exposed in the east end of the Vallecitos. It seems to the writer that the sandstone member (if regarded as a deposited sediment and not a clastic intrusion) together with its overlying associated shale may very well represent a younger formation than the Kreyenhagen below.

The third contact, which is a definite unconformity, divides this upper shale (overlying the peculiar sandstone described) from the so-called Leda zone. A clear exposure was found on Tumey Gulch. Here the contact was similar to the unconformity previously discovered by the writer on Domengine Ranch, where the white beds of Kreyenhagen diatomite are separated by the fossiliferous shale and sandy strata of the Leda zone. Pholas borings carrying sandy and gravelly material from an overlying layer are found in the finely laminated diatomite bed below.

The Leda zone appears to be limited to a few miles in width in the region about Domengine Ranch, and in an area north of Arroyo Ciervo. Though very thin and hardly mappable, the beds may represent a formation which once had a greater thickness and extent, for its patchy occurrence would indicate removal by erosion prior to Temblor deposition. Beneath the valley floor, concealed from view, it may now possibly extend in an unbroken series to the southern end of the San Joaquin Valley. Likewise, the sandstone and shale member lying between the Leda zone and the Kreyenhagen shale may underlie this same covered area.

The fourth contact divides the Leda zone from the Temblor sandstones. Though not always well exposed, it was uncovered on the south side of the gulch north of Arroyo Ciervo, where it shows distinct evidences of being an unconformity. A lateritic and peaty material separates the brownish limy and fossiliferous beds below from the coarse arkosic sandstones above. Fossils of the two formations are quite different.

Where the Leda zone is not present, the intervening sandstone and shale rest unconformably beneath the Temblor and where neither of these formations is present, the Temblor rests with distinct unconformity upon various members of the Kreyenhagen shale below. For the most part, north of Coalinga, the Temblor lies on the eroded surface of white diatomites, but on Reef Ridge, the contacted surface of

the Kreyenhagen reaches deeper into the lower phases of the formation to the harder cherty beds and brownish shales. The varying thickness of the Kreyenhagen along Reef Ridge shows this irregular erosion surface.

CORRELATIONS OF GEOLOGIC UNITS

The writer has found that wherever the stratigraphic positions of the fossils collected are considered in due respect to the unconformable contacts herein described, the correlations between horizons from place to place become much easier. It is not in the scope of this paper to enter into the detail of the fossil study, but to give the results of correlation as determined through comparative stratigraphy, checked by paleontologic study.

It would appear that above the fossiliferous beds of known Eocene age, there are at least three horizons which have at one time or another been considered as Kreyenhagen shale. Of these three, the lower may be called the Kreyenhagen proper, the second, an intermediate sandstone and shale member, and the third, the Leda zone.

The Kreyenhagen shale proper may be correlated, without any hesitancy (at least on the writer's part) with the Kreyenhagen shale (siliceous phase) of Reef Ridge and Canoas Creek, regarded as the first type locality of the formation.

The Leda zone is thought to be a much higher horizon, certainly not Eocene, and possibly correlated with Clark's Kirker formation of Mount Diablo, which contains a fauna classified by him as Oligocene.

The age of the intermediate sandstone and shale is more questionable. Because of its position and the presence of *Thyasira folgeri* W. & Sch., it might be correlated with certain sandstone beds questionably called Oligocene, which clearly overlie the Kreyenhagen shale proper west of Wagonwheel Mountain, near Devils Den. The beds might in turn be correlated (because of the presence not only of this one fossil but two or three others) with the lower horizon of the San Emigdio formation (which overlies the Tejon) in the southern end of the San Joaquin Valley. Though geologists have previously considered the San Emigdio to be San Lorenzo (Oligocene) in age, Woodring is inclined to place it as Eocene (62).

According to this reasoning, it would seem, therefore, that the Kreyenhagen shale proper should belong in the Eocene.

Below the lower contact of the Kreyenhagen shale proper, as the writer has termed it, are the true Eocene beds which (north of Coalinga) were originally correlated by F. M. Anderson (5) with the Kreyenhagen of Reef Ridge. (This particular correlation has now been abandoned by most geologists who know the area.) This means that sandy shales mapped by Robert Anderson and Pack north of Coalinga (19) as Martinez (?) were regarded by F. M. Anderson as Kreyenhagen shale. (Some of the adjoining Moreno shale (Cretaceous), were included in his original description.) Some of the foraminifera obtained from the Eocene shaly beds north of Coalinga are the same as those collected in more poorly exposed shales lying immediately beneath the siliceous Kreyenhagen beds on Reef Ridge.

The formation referred to by the Federal geologists as Martinez (?) was later regarded by Clark to be the same as his Meganos formation.

The sandstone, lying between the Kreyenhagen shale proper and this Meganos formation, and apparently thinning out near Oil City Camp, was mapped as Tejon, but is now regarded as Domengine by Clark (36) and others.

The sandstone beneath the Kreyenhagen shale proper on Reef Ridge and mapped as Tejon by Federal geologists, was originally called Avenal sandstone by F. M. Anderson (5). Many geologists correlate it with the Domengine. The writer sees no good reason to do otherwise, but until paleontologists agree on the correlation of fossils from the two localities, it may still be conveniently called locally the Avenal.

Unconformably beneath the Avenal sandstone on Big Tar Canyon lies the Cretaceous. Some Eocene deposits are found to the west, but their presence is due to the complicated structural conditions of the region.

At a certain locality, five miles southwest of Maricopa, the writer is inclined to believe that there is an isolated exposure of Kreyenhagen shale proper. The correlation has been based largely on stratigraphic position of the beds and comparative lithology. There is no fossil evidence whatsoever to check this assumption.

The diatomite beds which lie intercalated in the upper part of Clark's Markley formation of the Mount Diablo region (23), are apparently to be correlated with the white diatomites of the upper part of the Kreyenhagen shale proper. This assumption is based on the occurrence of diagnostic foraminifera and diatoms and also on stratigraphic evidence. There is, however, still a possibility that the Markley may be correlated with the intermediate sandstone and shale of the Cantua-Panoche district.

Beneath the Markley sandstone are some brown shale beds which might very well be correlated with the lower part of the Kreyenhagen proper. They lie above the sandstones first regarded by Clark to be Tejon (23), but now assigned to the Domengine.

None of the evidence seems to indicate an age younger than Eocene for the Kreyenhagen shale proper. The fossil micro-organisms of the formation are not all diagnostic, but a few of them indicate Eocene age (57, 58, 59).

EXTENT OF THICKNESS OF SURFACE EXPOSURES

On Reef Ridge, south of Coalinga, the Kreyenhagen shale (or 'upper member of the Tejon') is exposed continuously for 15 miles (13). It varies in thickness up to 1000 feet.

West of Wagonwheel Mountain, in the region of Devils Den, two small patches of the formation are exposed, having a thickness of about 850 feet.

Between the exposures on Reef Ridge and those of Devils Den, there is a gap, or lack of exposures, covering a distance of 12 miles. Another similar gap of 12 miles lies between Reef Ridge and the northern shale area in the region of Coalinga.

In a small area, south of the Elkhorn Plains, 5 miles southwest of Maricopa, is a series of brown shales, thought by the writer to be the Kreyenhagen. It reaches a thickness of 500 feet, exposed in length only for a fraction of a mile, and separated from the Devils Den beds by a distance of 55 miles.

The brown Kreyenhagen (?) shales of this southern region lie some 12 miles west of the type Tejon exposures.

In a recently-drilled well, located in the region of McKittrick, half-way between Devils Den and these exposures in the extreme south, is shown a series of shales which is apparently Kreyenhagen, though the formation is not present on the surface in the foothills. A straight line, however, drawn on a map and bearing N. 30° W., from these southernmost beds to the northernmost, would pass through nearly all of the surface exposures, though many long gaps occur between these exposures.

Exposures of the Kreyenhagen shale, as mapped by Anderson and Pack (19), extend in a narrow belt for a distance of 100 miles, from a point in Stanislaus County, 22 miles north of Pacheco Pass, southward to Coalinga, broken here and there by alluvial covered areas, and overlapped in places by younger formations. The maximum thickness of the Kreyenhagen shale is developed in the Cantua-Salt Creek-Domengine region, where it totals about 1800 feet. It is thought, by the writer, that this area may represent the center, or deepest part of the original basin of deposition.

The Markley formation, of the Mount Diablo region, together with the 'Tejon shale' of that area, as recorded by Clark (23) is in all 3760 feet thick. This section is thought by the writer to be probably the equivalent of the Kreyenhagen shale. At least the upper diatomite beds of the Markley appear to be equivalent to the upper white diatom shales of the Kreyenhagen.

At the opposite or southern end of the San Joaquin Valley, the sandstones of the Eocene type Tejon (thickness 3000 feet) (31) is thought by the writer probably to be the equivalent of the Kreyenhagen, though some geologists regard the San Emigdio sandstone (thickness also about 3000 feet) to be its correlative (29). There is still a third interpretation that is quite possible, *i.e.*, that the Kreyenhagen is not at all represented in the type Tejon area.

Besides the extensive sandstones of the extreme north and south ends of the basin of deposition, other sandy phases have been found, one of which lies near the west central part. Here, in the Vallecitos, near Idria, San Benito County, the formation, in part at least, becomes distinctly sandy. Abundant sandstone dikes and sills of that region intrude the shales and are not always easy to distinguish from bedded deposits. In some places they may originate from intercalated sandstone strata (60).

A total distance of 300 miles lies between the Markley exposures and the sandstones of the south end of the Valley, a figure which may be considered to represent the length of the basin of deposition from northern to southern shore. There have been evidences from other sources, however, which indicate deposition north of San Francisco Bay. This area will not be discussed in this paper.

Though it is not known whether or not the Kreyenhagen is continuously present beneath the Valley floor from the north to the south, the writer is inclined to believe that a continuous deposit occurs. In width, however, the formation appears limited. Apparently it is not present on the opposite side of the Valley. A few deep wells drilled in

the center of the great alluvial plain, some 30 miles east of the western exposures and a few miles west of Fresno, encountered the formation, but disclosed a thickness not greater than 200 feet (39). The width of the formation beneath the Valley may be, therefore, limited to about 40 miles.

LATERAL EXTENT OF THE FORMATION.

The fragmentary record of the geologic units under discussion indicates that they once extended at least from the Mount Diablo region to the southern end of the San Joaquin Valley. There are also indications that the shales grade into sandstones at the north and south limits and possibly westward, at least in the region of the Vallecitos. This change in lithology points towards shore line conditions in the area of sandstones, while the diatomites might represent a marine trough, though its depth may have been shallow.

For the reason that the Kreyenhagen shale and associated beds are among the lowest strata of the Tertiary, and all dip beneath the Valley floor of alluvium, 50 miles wide, the lateral extent of the Kreyenhagen can only be guessed. It does not appear, so far as known, on the east side of the Valley. It has only been found, in a few wells situated in the center of the Valley, 30 miles east of the outcrop some 15 miles west of Fresno (39). A thickness of not more than 200 feet has been assigned to the beds at this locality.

Though outcrops are discontinuous in the foothills on the western side of the Valley, there is no good reason to believe that the formation does not occur without break at depth beneath the less disturbed Valley region. As a matter of fact, recent drilling has disclosed the Kreyenhagen shale in the Valley close to the western hills, but opposite places where surface exposures show it lacking.

It does not seem unreasonable, therefore, to consider the possibility of lateral extent of the formation as much as 20 to 40 miles in width and 250 to 300 miles in length.

BIBLIOGRAPHY AND REVIEW OF PREVIOUS WORK BEARING ON THE KREYENHAGEN SHALE PROBLEM

(In the paragraphs which follow each reference, the small type represents quotations from the previous authors, while the larger type is employed for review and remarks by the present writer.)

1869

(1) W. M. Gabb, ''Cretaceous and Tertiary fossils,'' *Geol. Survey California, Paleontology,* Vol. 2 (1869), pp. 199–200.

Gabb described *Pecten interradiatus,* giving its type locality as follows:

> "From a buff-colored shale east of New Idria, at or very near the summit of the Tejon Group where I found it very abundant."

Later this shale formation was mapped by Anderson and Pack as the Kreyenhagen. The pecten occurs near the base, above the ''Tejon'' (Domengine) sandstone. In the same horizon (as this locality at the eastern end of the Vallecitos) this same species of pecten may be traced continuously to the exposures on Reef Ridge and near Devils Den.

1894

(2) W. L. Watts, "The gas and petroleum yielding formations of the Central Valley of California," *California State Mining Bureau, Bull. 3* (1894), pp. 60, 65, 66, 71. (See also *Bull. 19,* 1900.)

The formation (later known as Kreyenhagen) was illustrated and described, and six kinds of diatoms were listed, together with *Pecten peckhami* and a few fish bones. The Miocene sandstones were recognized as resting above, unconformably.

1896

(3) Timothy W. Stanton, "The faunal relations of the Eocene and Upper Cretaceous on the Pacific Coast," *U. S. Geol. Survey, 17th Ann. Rept., Pt. 1* (1896), p. 1027.

Stanton stated the *Mysia ? polita* Gabb was associated with *Pecten interradiatus* Gabb, "near the top of Tejon" in the region about New Idria. (See reference under Gabb.)

1903

(4) G. H. Eldridge, "The petroleum fields of California," *U. S. Geol. Survey, Bull. 213* (1903), p. 307.

Eldridge described the general geological conditions about Coalinga including a section in which the thicknesses of various shales are given, but it is difficult to tell just what was the part later designated as the Kreyenhagen.

1905

(5) F. M. Anderson, "A stratigraphic study in the Mount Diablo range of California," *Proc. California Academy Sci., 3d ser., Geol.,* Vol. 2, No. 2 (1905).

The first use of the name Kreyenhagen shale was made by F. M. Anderson in this publication. He said that "On account of its development at the Kreyenhagen wells this member of the Eocene has been termed the *Kreyenhagen Shales.*"

The exact location of the Krevenhagen wells was later given by Arnold and Robert Anderson (1910, p. 229) as follows:

> "The two wells of the Kreyenhagen Oil Company are located on Canoas Creek, in the SE. ¼ Sec. 32, T. 32 S., R. 16 E. Both wells start in the shale in the upper part of the Tejon, the southermost, well No. 1, beginning in the formation."

The Canoas Creek section is, therefore, generally considered the type locality of the Kreyenhagen shale. In this area, however, *i.e.*, along Reef Ridge, south of Coalinga, it has never been separately mapped as a formation by the United States Geological Survey. It was later referred to only and described in this area by Arnold and Robert Anderson as the "upper member of the Tejon."

Apparently, since the Kreyenhagen shale at the type locality was poorly exposed and contained but few fossils, F. M. Anderson attempted to describe it from another locality, namely, north of Coalinga near Oil City Camp. The shales of this northern locality were considered to be of the same horizon as the shale of Reef Ridge, but they are now considered by most geologists to be older, in part Eocene and in part Cretaceous. The lower northern shales are not even represented south

of Coalinga, according to the writer's opinion. Anderson's description, in this original paper, reads as follows:

"While the stratigraphic divisions of the Eocene do not continue regularly throughout, there is at least one member that is fairly well characterized along the whole extent of the series as far as has been followed. This member is the middle one, and consists of brown bituminous or carbonaceous shale, more or less sandy in the lower portion, and with a maximum thickness of 600 feet as exposed on the hills a few miles north of Coalinga. Farther to the south and southeast it varies considerably, attaining at the Kreyenhagen wells a thickness of about 900 feet, while on the head of the Jacalitos and on the Zapata Chino there are not more than 250 or 300 feet of strata. On account of its development at the Kreyenhagen wells this member of the Eocene has been termed the Kreyenhagen shales. The lithological character of these shales is not constant, as the proportions of the chief elements vary from point to point. Sands, clay, and organic matter, both calcareous and carbonaceous, make up the mass of the beds, which at some points sandy and at others argillaceous, while the percentage of lime or carbonaceous matter also varies.

"Nodular masses of calcareous rock and nodules of barites[1] ($BaSO_4$) are common in many places, and these form a characteristic feature of the shales.

"The calcareous masses occurring in the shales often contain Foraminifera in great numbers, not unlike certain rocks of the Miocene. The brown color of these shales is probably due in large part to bituminous matter contained therein." . . .

Some of the foraminifera were from the lower section of Eocene shales (Meganos) and some from the Moreno (Cretaceous) shales.

"At the sulphur spring in one of the canyons of Zapata Chino Creek the Eocene is represented by the following members:

Kreyenhagen shales	250 feet
Avenal sandstones	500 feet
Basal	15 feet

"In the areas extending northward from Coalinga the Avenal sandstones have been only indirectly proved. At the coal mines the basal portion of the Eocene is occupied by thin beds of conglomerate, sand, and coal-bearing sandy shale. The following stratigraphic section fairly represents the Eocene at the coal mines:

Kreyenhagen shales	400 feet
Echinoderm conglomerate	8 feet
Carbonaceous sands	140 feet

"North of Los Gatos Creek a pebbly conglomerate six to ten feet thick near the top of the Kreyenhagen shales, has been followed almost continuously for a distance of four miles."

The list of species Anderson cited from this bed last described showed that it was Eocene. His local correlation, however, has been questioned, for he applied the name Kreyenhagen to a new series of shales coming in under the Eocene sands rather than above them.

"On the N.E. ¼ Sec. 17, north of Coalinga, similar pebbly beds just above the top of the Kreyenhagen shales contain a few of the foregoing species along with species of Foraminifera and nodules of barites."

This sandstone horizon, he said develops northward and

"in the vicinity of the Domijean ranch affords grounds for its designation as the Domijean sands."

Following these beds northward to New Idria and along the southern side of the Big Panoche Valley, Anderson divided the Eocene as follows:

	Feet
Loose ash-colored sandstones	300
Carbonaceous clay shales	300
Sandstone (ash-colored)	600

He called these beds by the following names:

Domijean sands
Kreyenhagen shales
Avenal sandstone

[1] Barite was not found by the writer in the Kreyenhagen shale proper, but in the Moreno (Cretaceous).

But it must be remembered that these particular beds are all below the shales mapped later by Robert Anderson and Pack as Kreyenhagen.

Now let us turn to F. M. Anderson's description of the beds he mapped as Miocene. These were later mapped as Kreyenhagen.

> "Two members of the Miocene have been detected in the Coalinga district proper, but possibly others occur a few miles northwest. For the most part the Temblor beds are not present and the following members only are in evidence, as in the vicinity of the Kimball wells, where the following members occur:

	Feet
(?) Contra Costa beds	
Monterey shales	800
Domijean sands (Eocene)	1200

> "Ashy beds near the top of the Miocene resemble both lithologically and faunally beds on the bay-shore north of Pinole Station, Contra Costa County. The following species were collected from these Miocene beds on the west side of Sec. 19, T. 18 S., R. 14 E:

Ashy beds	Monterey shales
Leda oregona (?)	*Pecten peckhami* Gabb
Tellina congesta (?)	*Callista* (?)

> "The noteworthy facts about the Miocene series north of Coalinga as far as followed are the absence of Temblor beds and the greatly reduced thickness of the Monterey shales."

Here we see "ashy beds" above the shales carrying *Ledas.* This is probably the same *Leda zone* (referred to by the writer) that was later examined by Ruckman and identified by Clark as Oligocene. In 1908 Anderson suggested the possibility of the shale series being Oligocene, but did not correlate it with his Kreyenhagen south of Coalinga.

1906

(6) Ralph Arnold, "The Tertiary and Quaternary Pectens of California," *U. S. Geol. Survey, Prof. Paper 47* (1906), pp. 55–57.

Arnold recorded *Pecten interradiatus,* as Gabb originally described it from the New Idria locality. It is also stated that H. W. Turner collected it there from the same locality. The "hard, dark-colored shale" referred to was later mapped as Kreyenhagen.

1908

(7) Ralph Arnold, and Robert Anderson, "Preliminary report on the Coalinga oil district, Fresno and Kings counties, California," *U. S. Geol. Survey, Bull. 357* (1908).

The results of this report were repeated, modified and extended in the later final reports by the authors. The conclusions reached at this time regarding the correlation of the "shale overlying the sandstone known to belong to the Tejon formation," were as follows: The unconformity between this shale and the overlying Miocene sandstone was said to be profound. The age of the shale was thought to be Eocene

> "because it is in apparent continuity with the beds of that age, because it is found in association with those beds wherever they occur, because it underlies unconformably beds containing fossils of lowest Miocene age, and because it contains fossils that point to its Eocene age. It is thought not probable that it belongs in the Oligocene, because rocks of that age have not been recognized in the Coast Range south of the Santa Cruz Mountains."

It was observed that on Reef Ridge

> "the tilting of the shale beds is in general steeper and the disturbance greater than in the Miocene above."

The importance of this shale member, as a source of the petroleum of the Coalinga district, was fully recognized by the authors. They said that

> "Petroleum has not been found in this district except in beds associated with the Tejon, and where the Tejon is absent the beds of the other formations are dry."

The Tejon referred to was, in this case, the Kreyenhagen shale, as it was later known.

(8) Frank M. Anderson, "A further stratigraphic study in the Mount Diablo Range of California," *Proc. California Academy Sci., 4th ser.*, Vol. 3 (1908), pp. 15–17.

In the area north of Coalinga, on Cantua Creek, east of the Lillis ranch house the diatomaceous shales (later mapped by Robert Anderson and Pack as Kreyenhagen) were tentatively assigned

> "to either the Eocene or the Oligocene in the time scale of California geology. . . . Stratigraphically and structurally they are certainly connected closely with the Tejon series, while faunally they are allied more closely to the Miocene."

The series was divided into upper white chalky shales, 800 feet thick, and lower brown clays, etc., 1000 feet thick. A marked unconformity was recognized between this series and the overlying sandstones. The thickness of the shales was said to decrease southward.

> "In the vicinity of the Domengine ranch, they are reduced to about 1000 feet, while at 'Oil City' the thickness is not above 600 feet. * * * The fauna of these shales consists of many forms of Forminifera and marine diatoms, but with a scanty number of mollusks."

Pecten peckhami was found in the white shales together with many foraminifera and diatoms on Cantua Creek and at Oil City.

> "Intermediate between these two localities, on Sec. 19, T. 18 S., R. 15 E., these white shales have furnished:
>
> *Pecten peckhami* Gabb — *Tellina congesta* (?) Conrad
> *Leda oregona* (?) Shum — *Callista* sp.
>
> "It was these upper brown and white shales which, on the basis of both their lithology and their molluscan fauna, were regarded as Miocene, and therefore as 'Monterey shales,' in the former paper. Had the succeeding Lower Miocene series been as fossiliferous, however, as new localities have since shown it to be, or had it been followed into the localities where the great unconformity is more evident, it would have been less easy to confuse these earlier shales with their counterparts in the Miocene."

Apparently the four fossil mollusks listed were from the same general locality that Ruckman later secured his collection. The mollusks Ruckman found in the shales were used by Clark to prove the Oligocene age of the beds. Among these were a *Leda* and a *Macrocallista*. These were probably from the same beds as Anderson's *Leda* and *Callista*, and the present writer has shown that the beds containing these fossils lie above the Kreyenhagen, unconformably.

1909

(9) William Healey Dall, "Contributions to the Tertiary paleontology of the Pacific Coast. 1. The Miocene of Astoria and Coos Bay." *U. S. Geol. Surv., Prof. Paper 59* (1909), pp. 142, 143.

In listing the genera of foraminifera from Millers Beach, Coos Bay, the statement was made that the

> "Genera observed were *Cristellaria, Cyclammina, Pulvulina,* and *Polymorphina*, an assembly recalling that indicated by Anderson in his study of the Eocene rocks of the Mount Diablo Range in California as occurring in the Kreyenhagen shale."

It was also stated that no foraminifera were found in the Eocene underlying the Oligocene of Millers Beach. The Kreyenhagen shale referred to is not the diatom shale mapped by Robert Anderson and Pack north of Coalinga, and correlated by them to F. M. Anderson's Kreyenhagen shale south of Coalinga, but is the older Eocene shale

lying below the diatomite shale (north of Coalinga) and has since been reassigned to the Eocene by Cushman and Hanna in 1927.

(10) Ralph Arnold, "Paleontology of the Coalinga district, Fresno and Kings counties, California," *U. S. Geol. Survey, Bull. 396* (1909), pp. 12–16, pl. 23.

The Tejon formation was divided

> "into a lower sandstone portion and an upper shale portion, but no sharp division can be made that will be applicable throughout the district under discussion."

(This upper shale portion comprises the beds later referred to by Robert Anderson and Pack as the Kreyenhagen shale, after F. M. Anderson's original naming of the formation). The Tejon was said to have a total thickness of 1400 to 2300 feet,

> "the upper half of which is made up of whitish and purplish, siliceous, argillaceous, and locally calcareous shale which is easily recognizable and which lends individuality to the formation * * *. "The upper shale is very similar—especially so in some places, as north of Coalinga—to the siliceous shale of the formation along Reef Ridge described later as the Santa Margarita(?), and the two must not be confused."

In the following locality (undoubtedly in the Kreyenhagen shale as later mapped)

> "4616. Eight miles due north of Coalinga, one-half mile east of Oil Canyon road, and just north of Laval-grade, near center of SE. ¼ sec. 20, T. 19 S., R. 15 E. Siliceous shale in upper portion of Tejon"

two fossils were listed from this formation, i.e., *Pecten interradiatus* Gabb, and *Pecten peckhami* Gabb. Locality

> "5014. About 13 miles north of Coalinga, on east side of sec. 29, T. 18 S., R. 15 E., in dark-colored shale just under Miocene oil sand,"

one fossil was listed, i.e., *Leda gabbi* Conrad. It is the present writer's opinion that this is probably the same fossil from the same locality recorded first as *Leda oregona* (?) Shum, by F. M. Anderson in 1908, then as *Leda gabbi* v. *sanborenzoenus* nv. by Ruckman in 1914 (unpublished), and later as *Leda washingtonensis* Weaver by Clark in 1918, and still later changed by him to *Leda lincolnensis* Weaver.

In conclusion, as regards the age of the shale, Arnold said:

> "The molluscan fauna of the white diatomaceous and foraminiferal shale at the top of the Tejon in the Coalinga district consists of *Pecten interradiatus* Gabb, *Pecten peckhami* Gabb, and *Leda gabbi* Conrad. *Leda gabbi* is a common Tejon species, while *Pecten peckhami* is so far known elsewhere only in the Oligocene, Miocene, and possibly Pliocene. *Pecten interradiatus* is known elsewhere only in shales occupying a similar stratigraphic position to the shales in which it occurs in the Coalinga district. The stratigraphic evidence is in favor of the diatomaceous shales being a part of the Tejon. The faunal evidence is about equally divided; therefore, it seems most logical that the rocks in question be assigned to the Tejon, at least until the securing of further and more definite evidence."

The three fossils above noted (two pectens and one leda) represent, according to the present writer's own observations, three different and distinct zones: the first a lower zone, the second an upper zone, both in the Kreyenhagen shale, whereas the third is confined to an uppermost layer separated from the thicker series below by an uncomformity.

(11) Ralph Arnold, "Environment of the Tertiary faunas of the Pacific Coast of the United States," *Jour. Geol.*, Vol. 17 (1909), pp. 515, 531.

Arnold said that the diatomaceous shales which occur

> "at the top of the Eocene series in the vicinity of Coalinga, California, * * * are believed to be the source of important deposits of petroleum."

(This refers to the Kreyenhagen shale.)

1910

(12) Ralph Arnold, and Harry R. Johnson, "Preliminary report on the McKittrick oil region. Kern and San Luis Obispo counties, California," *U. S. Geol. Survey, Bull. 406* (1910), pp. 40, 41, 44, 72, pl. 1.

Southwest of Wagonwheel Mountain, in the region of Devils Den, the authors recognized rocks of possible Oligocene age.

> "Here a series of massive light-gray and buff non-nodular sandstones, inclosing a fossiliferous reef, are overlain by yellowish and cream-colored calcarceous shales. The latter grade upward into gypsiferous gray shales and sandstones that immediately underlie the reef beds of the Vaqueros, separated from the latter by a layer of small black, slaty pebbles * * *"

A section given in the report indicates the different beds by numbers, 1–15.

> "The fossils found in the basal beds of this series are as follows:
> *Lima* sp. indet.
> *Petricola* n. sp.
> *Phacoides* n. sp. aff. *californica* Conrad.
> *Thyasira* n. sp. aff. *bisecta* Conrad.
> *Fusus* sp. indet.
> "In a light-brown shale beneath a bluish diatomaceous shale in the NW. ¼ sec. 1, T. 26 S., R. 18 E., the following fossils were collected:
> *Pecten peckhami* Gabb.
> *Terebratalla* n. sp.
> Fish scale.
> Shark's tooth.
>
> "With the exception of *Pecten peckhami* Gabb, which ranges from the Eocene or Oligocene to the Miocene, the stratigraphic position of none of the fossils mentioned is known. The stratigraphic affinities of the beds are with the Eocene, and while the paleontologic are with the lower Miocene, they are possibly to be correlated with the white diatomaceous shale tentatively mapped with the Tejon in the Coalinga district, and may possibly be of Oligocene age."

In attempting to verify the above statements, the writer examined the area and found the Kreyenhagen shale proper (known as the "upper member of the Tejon," in the earlier reports) to lie beneath the sandstone bed (recorded as No. 15) described as the "basal beds of this series." Numerous specimens of *Pecten interradiatus* occur in the lower strata of the Kreyenhagen shales, just northwest of Wagonwheel Mountain, which fact was not listed in the report. Between beds designated in the section as numbers 6 and 7, is an unconformity, marked by the presence of pebbles of shale (resembling the chocolate shale of the series) in the sandstones above. The facts have led the writer to consider the series (from number 7 to number 15 of the section) to represent a distinct formation overlying the true Kreyenhagen shale and underlying the Miocene sandstones.

The fossils occurring in the "basal beds" of the sandstone resemble some of the fossils found in the basal beds of the San Lorenzo section on San Emigdio Creek, for example: *Phacoides inflata* W. & Sch. and *Thyasira folgeri* W. & Sch. These sandstones may possibly be correlated with the beds in the Cantua-Panoche region designated by Condit as the "C" horizon.

Another area represented in the geological map presented by Arnold and Johnson as possibly Oligocene, occurs about six miles west of Simmler, but this has since proved to be Temblor.

Five miles southwest of Maricopa the Santa Margarita formation (questionably so marked) is recognized west of a mapped fault. The writer has verified definitely the presence of the fault and also the age (Santa Margarita) of the contorted shales and granite-boulder formation to the west. East of the fault, however, is a thick series (overturned) of sandstones representing the Lower Miocene and possibly in part the San Emigdio. A series of chocolate-colored shales occurs at the base of this section, under the westward dipping fault and above the recumbent sandstone layers. These shales are highly bituminous in character, some 450 feet in thickness, resemble the Kreyenhagen shale in lithologic character, and apparently lie in the same position in the stratigraphic column. An older sandstone series, resting in a recumbent position on top of these shales, contains large spherical concretions and may possibly represent the Eocene or even Cretaceous.

(13) Ralph Arnold, and Robert Anderson, "Geology and oil resources of the Coalinga district, California," *U. S. Geol. Survey, Bull. 398* (1910), pp. 47, 62–75, 164, 183–184, 188–189, 227–232; pls. 1, 5, 6, 7, 13, 14, 24 and 25.

The same data on paleontology published the year before were repeated in this report together with some supplementary information. A map of the region covering the area both north and south of Coalinga was included, but the upper shale member of the Tejon was not differentiated. The Tejon formation was described on the map as

> "sandstone, sand, clay, gravel, and siliceous and calcareous diatomaceous and foraminiferal shale."

A columnar section showed no unconformity between the shales and the sandstones of the Tejon, but did indicate distinct unconformity above and below the whole Eocene group.

A graphic section across Reef Ridge, together with an explanatory description divided the Tejon series as follows:

(Above, unconformable upon the shale, lies the Vaqueros).

Thinly bedded purplish, dark grayish brown, and locally light-brown and yellowish siliceous, calcareous, and argillaceous shale	700 feet
Grayish-brown sandy clay shale	125 feet
Light-gray, yellowish, and brown, locally concretionary and fossiliferous sandstone impregnated with oil	500 feet

(The Cretaceous is shown beneath these beds.)

The writer's own investigations verified this section and in the lower portion of the upper shale group were found numerous specimens of *Pecten interradiatus.* The middle member contained well-preserved foraminifera in its sandy clay shale, whereas the lower sandstones were filled with various forms of typical Eocene fossil mollusks. The upper shale member of Reef Ridge is considered by the writer to be the Kreyenhagen shale proper. Eocene foraminifera from the middle clay shale series have led various paleontologists to regard the Kreyenhagen as Eocene in age, but the writer places these clay shales below the contact.

On plate 5 of the report, a clearly defined unconformity is shown as occurring between the shale and the Vaqueros sandstone. Typical sandstone dikes and typical structural disturbances so often occurring

in the shale are illustrated on plate 6. An error, however, was made in the explanatory diagram to plate 13. The picture shows clearly the diatomite shales in an exposure north of Coalinga. The unconformity and the "Vaqueros petroliferous gravel and sand" do not occur as shown in the explanatory diagram, though they are present in the foreground. The upper part of the shales (shown in the left part of the picture) are beds of white diatomite containing *Pecten peckhami,* and are not of "gravel and sand."

The name Kreyenhagen shale was not employed by the authors of this report, but they referred to F. M. Anderson's first report on the region, showing that he divided the Eocene into three members,

> "the Avenal sandstone at the base, the Kreyenhagen shales in the middle, and the Domijean sands at the top. The first two of these names were applied to the two members of the Eocene along Reef Ridge in the southern half of the Coalinga district. North of the region those members were correlated with the * * * upper concretionary sandstone and the overlying purple-shale member of the Chico (Upper Cretaceous). The third of these names was applied to the Eocene sandstones near the Domengine ranch, just north of Coalinga, this sandstone being considered to represent an upper sandstone zone."

The author considered this sandstone as the upper portion of the lower member of the Eocene, and the shales overlying as the upper member of the Eocene.

The "upper shale member" was described as a belt north of Coalinga of white shale, varying in thickness from 400 to 1000 feet thick, the variation being

> "due to the erosion that took place before the deposition of the Miocene * * *. This member consists chiefly of white, siliceous, hard and brittle thinly bedded diatomaceous and foraminiferal shale, interbedded with finely fractured, roughly bedded purplish-brown clayey shale, some fine and coarse sand, and thin calcareous shale layers * * * . The shale is locally variable in color, assuming different yellowish and reddish tints as the result of staining by petroleum. It contains an abundance of crystallized gypsum, with minor amounts of alkaline mineral matter and sulphur along the intricate fracture planes. Some of the beds are largely composed of gypsum. Dikes of sandstone traversing the beds in various directions are so common as to be characteristic of the formation."

An analysis of the chocolate-colored shale showed it to contain about 78 per cent of silica, composed

> "largely of diatom remains with foraminiferal tests in minor number. The silica is probably chiefly the product of the siliceous skeletons of the diatoms."

In the Reef Ridge area, the shale overlying the Tejon sandstone was described as being less resistant to weathering than the sandstones above and below it, and

> "marked by few outcrops and is almost bare of vegetation, except grass and scattered small juniper and oak trees * * * . At the base the beds of this member are almost invariably poorly exposed, but they seem somewhat sandy through a thickness of about 200 feet, as if representing a transition from the sandstone of the lower member. Above this transition zone the beds are fine-grained argillaceous shale, of a peculiar dark purplish brown, and similar to some of the shale in the upper member of the formation north of Coalinga. Thin laminae of fine sand are occasionally intercalated. The shale is usually comminuted into fine flakes or locally almost into a powder. It has a black carbonaceuos appearance in places, this and the purple color possibly being due to the impregnation with petroleum. The cracks in the shale are frequently lined with sulphur.* Toward the top the shale becomes yellowish or whitish in places, for example, near and southeast of Big Tar Canyon, and both siliceous and calcareous, the latter variety containing innumerable foraminiferal remains. These beds bring out still more strikingly the resemblance to the shale member north of Coalinga, and indicate that the same horizon is represented in both localities. The thickness of the beds exposed between the sandstone of the Tejon and the Miocene varies from place to place along Reef Ridge.

* Probably the mineral jarosite and not sulphur (the writer's note).

> The maximum thickness that has been found is in the neighborhood of Canoas Creek, where it is about 1000 feet."

The oil of the Coalinga district was believed by these authors to have originated from two different sources

> "namely, the organic shales forming the uppermost member of the Chico (Upper Cretaceous) and those described as the upper portion of the Tejon (Eocene)."

Several oil zones were named, Chico, Tejon, Vaqueros, Santa Margarita, and Jacalitos, but these represent accumulation horizons.

The Tejon oil zone of the Oil City field lies above shales of both Cretaceous and Eocene ages, whereas the Tejon oil zone of Reef Ridge overlies no such shales (so far as surface outcrops show), but in both cases they are overlain by organic, petroliferous shales. The oil of the Oil City field is described as

> "An amber-colored oil of 45° to 48° Baumé gravity * * * the highest oil in the Coalinga district and among the lightest in the State."

The oil of Reef Ridge, as represented by that from the Tejon oil zone in Canoas Creek

> "is said to be light-green oil, gravity between 37° and 38° B."

From another location in this same horizon, however, the oil was described as an amber-colored oil of 20° B. In the case of the Oil City field, the source of the oil is probably the shales of older age than the Kreyenhagen.

The source of the oil occurring in the Vaqueros zone is probably the shales of the "upper member of the Tejon" or Kreyenhagen shale, the name of later usage. The results of chemical and physical examination of the Coalinga oils were given in this report by Irving C. Allen in an extended table. The authors stated that the oil

> "from the Vaqueros varies in gravity from 14° to 22° in the Westside field, and from 14° to 31° in the Eastside. It is black or dark brown and the production averages between 100 to 200 barrels per day. One well in the Eastside field is now flowing 3000 barrels of oil per day and an initial yield of 7000 barrels in 18 hours was recorded for another well in the same field * * *. The Silver Top well, in the south end of the Westside field, yielded at the rate of 20,000 barrels a day for a few hours during its initial flow."

1911

(14) Robert Anderson, "Preliminary report on the geology and oil prospects of the Cantua–Panoche region, California." *U. S. Geol. Survey, Bull. 431* (1911), pp. 67–68.

A thick body of diatomaceous shale (later mapped as Kreyenhagen shale) which lies along the northeast flank of the Diablo Range for 50 miles north of Coalinga, was described and questionably assigned to the Eocene. Though in earlier government reports it was considered as the upper member of the Tejon formation, it was here recognized as a separate and prominent stratigraphic unit, particularly important because its strata, being very petroliferous, and located beneath the oil sands of the "Vaqueros," represents the source material for the petroleum of the Coalinga district. The formation has an average thickness of 1000 feet. The following description summarized the character of the formation:

> "Its principal constituent is white or brownish, thinly laminate diatomaceous shale in every respect like Monterey shale (middle Miocene) of the

outer Coast Ranges, including all gradations from a soft white 'diatomaceous earth' to porcelaneous shale and black flint. The unaltered or only partly silicified shale is predominant. Shale of less purely organic origin, in which argillaceous and even sandy material is abundant, is interbedded in the formation, especially in its lower half, which in places assumes a purplish-brown or locally even a dark color. Calcareous layers and concretions are numerous, and in places in the formation gray sandstone is an important constituent. Sandstone dikes are also numerous. In places there is a marked appearance of a gradation between the fossiliferous Eocene white sandstone and this overlying shale. This close relationship may indicate that the shale is of Eocene age."

1912

(15) Robert Anderson, "Preliminary report on the geology and possible oil resources of the south end of the San Joaquin Valley, Cal." *U. S. Geol. Survey, Bull. 471-a,* Part II (1912), pp. 117–118.

In discussing the relation of the Tejon to the possibility of finding oil, Anderson said:

"In the vicinity of San Emigdio Creek a body of shale with interbedded layers of sandstone and some conglomerate, making up a formation over 700 feet thick, constitutes the base of the Tertiary, below the known Miocene and in what is believed to be the Tejon formation (Eocene), although definite evidence of its stratigraphic relations was not obtained. This shale bears some resemblance to the more impure facies of the organic shale found in the producing California oil fields and very likely contains a small proportion of material of organic origin."

This suggested the correlation of the Kreyenhagen shale with the Eocene near the type Tejon locality.

(16) E. T. Dumble, "Notes on Tertiary deposits near Coalinga oil field and their stratigraphic relations with the upper Cretaceous." *Jour. Geol.,* Vol. 20 (1912), pp. 28–37.

In describing the Tejon of the Salt Creek-Cantua region, two members of the series were recognized, i.e., the lower white sand and conglomerate member, and the upper white shale. The shale member, later mapped by Robert Anderson and Pack as the Kreyenhagen, was described in Dumble's section as follows:

White fissile organic shales, containing fish scales, teeth, foraminifera, etc.	500 feet
Lenses of fine brown sand.	
White shale with local thin sandy strata	1000 feet
Local friable sand	30 feet
Pink to white shale	200 feet
Bluish sandy shales grading up into pink shales	40 feet
	1770 feet

A marked unconformity was recognized between this shale and the overlying Miocene sandstones, but the lower sandstones were considered to lie conformably below. While the sandstone was assigned to the Tejon, fossil evidence was insufficient to give accurately the age of the shales, although they were tentatively assigned to the Oligocene.

1914

(17) John Hamilton Ruckman, "Faunal succession of the Coalinga East Side field, Fresno County, California." A *thesis* submitted in partial satisfaction of the requirements for the degree of Master of Science at the University of California, May, 1914. (Cross section running diagonally across sections 8 and 4, T. 19 S., R. 15 E., and sections 34 and 36, T. 18 S., R. 15 E.)

This thesis of Ruckman's was never published, but has been referred to in publications by others (i.e. Dickerson in 1916, and Clark in 1918

and later). The results of Ruckman's work were, naturally enough, later modified by geologists after examining and using his material. It is interesting, therefore, to study his own data as recorded in his original paper. Under the heading, Eocene-Oligocene, he described the "Lillis group," which, he said, includes the "Domengine sands" and the "Oil field shales." In the Domengine sands he recorded a list of Eocene fossils from very fossiliferous conglomerates and sandstones. In the same group, but just beneath the Oil fields formation, he listed some fossils from "white limestone concretions" one foot thick. The following names are given by Ruckman from this particular bed:

Trochocyathus striatus ? Gabb
Turritella buwaldana n. s. Dickerson
Glycimeris cor Gabb
Crassatellites mathewsoni Gabb
Nodosaria sp.
Cyclamenia sp.
Coscinnodiscus sp.

Between this bed and the following Oil fields formation, he said that there is every evidence of conformity. This next formation he described as comprising white and brown diatomaceous shales overlying the Domengine sands and underlying the Temblor oil sands. (It is apparent that this formation corresponds to the Kreyenhagen shale as mapped by Robert Anderson and Pack). The detailed section of this portion of the stratigraphic column was given as follows, rearranged so as to show the younger layers on top:

Lying above is the Temblor sandstone of the Monterey series. Conglomerate at the contact, slightly irregular. Change in lithology abrupt. Lower Leda zone truncated. Long interval.

100 feet—Shale, growing more gritty. Fine-bedded. Near upper part, calcareous lenses and concretions carrying fauna. Sandstone dikes,
Leda gabbi v. *San lorenzoensis* nv. abundant
Macrocallista pittsburgensis Dall.
Haminea petrosa Conrad
Fusus merriami n.s.
Polynices clarki n.s.
Ranella cf. *cowlitzensis* Weaver
Turris dickersoni n.s.
Psammobia ? *domengenensis* n.s.
Ostrea sp.

100 feet—Shale, brown, black, bituminous, very platy, highly organic, forams and diatoms, minute crabs and fish scales abundant. Some terrigenous material.

100 feet—Shale, soft, brown, weathering white, organic substances chiefly forams and diatoms.
Coscinodiscus common
Cleavage planes show minute crabs and fish scales.

200 feet—Chert, hard, platy, weathers white. Bedding ¼″ to 2″ thick. Highly diatomaceous. Varies in texture to soft and earthly material.
Pecten peckhami Gabb, very abundant

150 feet—Shale, chocolate, soft, becoming harder and more cherty. Bedding becoming thicker, developing parallel cleavage. Organic content increases while terrigenous declines. Topography characterized by slides. Grades up into chert.

150 feet—Chiefly terrigenous shale.

3 feet—Hard, gray, and yellow; resistant to weathering. A very persistent bed.

120 feet—Shales, chocolate, very fine-grained, thin-bedded, wrinkled, soft fracture shaly. Organic content increasing.

1 foot—Sandstone, gray, fine-grained, unconsolidated. Quartz, feldspar, biotite, and black jasper. Organic remains.

20 feet—Shale, chocolate, very fine-grained, some glass, much terrigenous sediments, some diatoms. Bedding thin, fracture shaly. Small forams abundant.

1 foot—Sandstone, gray, fine-grained, unconsolidated. Quartz, feldspar, mica, black jasper, some siliceous organic remains.

3 feet—Fine-grained, chocolate shale, largely of minute glass. Little siliceous organic material. Some fine-grained terrigenous sediments. Bedding thin. Fracture shaly.

1 foot—Sandstone, green-gray, green, unconsolidated. Very fine-grained quartz, feldspar, biotite and black jasper. Some siliceous organic remains. Stained yellow.

2 feet—Deposits of gypsum, chiefly secondary in fine-grained bedded shale.

Beneath this series lie, with apparent conformity, the Domengine sands (as above explained).

This section is certainly clear and accurate. Before having seen Ruckman's section, the writer examined similar sections in the same general region and it appeared that Ruckman obtained important evidence in stratigraphy that should not be overlooked. In the examination was found an exposure made clear by a landslide showing the contact between the upper Leda zone and the lower shales. Above the contact is a thin conglomerate and sandstone layer and below it is a series of white laminated diatomaceous shale, the old surface of which is riddled with *pholas* borings. The contact was slightly irregular and is undoubtedly an unconformity. The contact between the Leda zone and the overlying Miocene sandstones was not clearly exposed here, but beds between the Leda shale zone and the Miocene sandstone were other beds of the same (Leda) formation, consisting of white, tuffaceous sandstones carrying molluscan fossils. This interesting, but thin, stratigraphic unit could be followed only a few miles.

Clark (1918 and later) assigned the age Oligocene to the whole (Kreyenhagen) shale series, basing the evidence principally upon the fossils which Ruckman found in the uppermost beds. Three of these fossils, *Fusinus (Exilia) lincolnensis* Weaver, *Macrocallista pittsburgensis* Dall, and *Leda lincolnensis* Weaver, also called *Leda washingtonensis* Weaver, served as his chief evidence.

Dickerson (1916), on the other hand, referred to Ruckman's collection of *Trochocyathus* cf. *striatus* Gabb and *Crassatellitos (Astarte) mathewsoni* Gabb as evidence that the Kreyenhagen shale series in its lower portion was Tejon in age, though the upper portion yielded fauna characteristic of the Oligocene. He stated that Ruckman collected these two fossils from "white shale beds immediately overlying the white Tejon sandstone," but Ruckman really said that the fossils were from "white limestone concretions" just beneath the shale series and within the series of the Domengine sands.

Ruckman further said that if no break occurred between the Domengine sand and the shales above, the shales should correspond to the Ione (*Siphonalia sutterensis* zone). Some of the silica or fragmental feldspar in the beds he attributed to volcanic ash. He felt that the presence of foraminifera and of *Pecten peckhami* indicated a warm sea of considerable depth, perhaps 200 fathoms, but this condition was brought about gradually from the more near-shore deposits of the underlying sandy beds. The overlying Leda zone, sandy and limy in character, would then represent the return of shallow, near-shore conditions.

Ruckman said that this upper limy Leda zone is "certainly equivalent to the upper San Lorenzo of California or the upper Lincoln of Oregon" and therefore should suggest a hiatus at the base of the whole shale series, between it and the Eocene, "but all stratigraphic evidence gathered at present is to the contrary." The fact that the hiatus occurs directly beneath the Leda zone as the present writer's own observations indicate, apparently was not known to Ruckman.

(18) Roy E. Dickerson. "Fauna of the Martinez Eocene of California." *Univ. Cal. Publ., Bull. Dept. Geol.*, Vol. 8 (1914), p. 108.

The fossil, *Pecten interradiatus* (Gabb), was listed by Dickerson with the Martinez localities. Even the type locality of the fossil was placed as Martinez in this list. This is erroneous, however, for its

locality (near New Idria), is in the Kreyenhagen shale, overlying Eocene sandstone and underlying, unconformably, beds of Miocene age.

1915

(19) Robert Anderson, and Robert W. Pack, "Geology and oil resources of the San Joaquin Valley north of Coalinga, California." *U. S. Geol. Survey, Bull. 603* (1915), pp. 27–28, 67–80, 129–133, 141–147, 161–186, 194–203; figs. 2, 3, 4; pls. 1, 2, 3, 6, 8, 9, 10.

The diatomaceous shale series which lies between the Tejon sandstone and the Miocene sandstone, was

> "designated Kreyenhagen shale, from its type locality in the Kreyenhagen field south of Coalinga,"

and was accurately mapped north of Coalinga along the foothill belt of the eastern side of the Mount Diablo Range as far as a certain point north of Pacheco Pass. The mapping included also the Vallecitos region. This report dealt with the Kreyenhagen shale in a thorough and comprehensive manner, because the formation was regarded to be of utmost importance in relation to the study of the occurrence of petroleum in this whole area.

A graphic generalized section of the southern part of the area described the Kreyenhagen as

> "marine diatomaceous and clay shale; somewhat sandy near the base and cut by numerous sandstone dikes."

A corresponding section for the northern part of the area, described it as

> "marine white or light-brownish, diatomaceous and foraminiferal shale bedded with a little fine-gray sandstone and cut by numerous dikes of fine-grained gray sandstone."

The formation was shown to be bounded by a well-defined unconformity above, but separated from the Eocene sandstones below by a questionable unconformity. The Kreyenhagen was assigned questionably to the Oligocene. It was accredited as being a "probable source of asphalt oil," whereas the Moreno (Cretaceous) shale was considered as a "probable source of light oil."

Photographic evidence showed clearly the appearance of the shale, its unconformable relationship with the overlying Vaqueros sandstone, and the occurrence of numerous sandstone dikes in the formation. Its characteristic crumpling was also well depicted. A correlation table brought out clearly how the name Kreyenhagen was formerly used by F. M. Anderson and later by Government geologists.

The authors gave the following reasons for treating the Kreyenhagen shale as a separate formation:

> "(a) that it is a homogeneous body of strata of marked persistency, evidently deposited in one basin under constant and rather unusual conditions during a continuous epoch of sedimentation;
> (b) that it is separated faunally from the formation above and below;
> (c) that it is probably unconformable on the Tejon formation (later Eocene) below and is marked off by a very important unconformity from the Vaqueros formation (lower Miocene) above; and
> (d) that it constitutes an excellent cartographic unit."

It was stated that earlier writers (Watts, Eldridge, and F. M. Anderson) considered the shale to be of the Monterey (Miocene) group, but that F. M. Anderson

> "on further study recognized its Eocene or Oligocene age."

The shale was believed

> "with little doubt to be the equivalent of the formation along Reef Ridge,"

south of Coalinga, that was formerly designated as the Kreyenhagen shales by F. M. Anderson and the "upper member of the Tejon" by Arnold and Robert Anderson. It was brought out, however, by Anderson and Pack that in the first report by F. M. Anderson (1905) the name Kreyenhagen was applied to

> "two different formations, one of Tertiary shale, exposed in the Kreyenhagen region, south of Coalinga, and the other of shale similar lithologically but of Cretaceous age, occurring north of Coalinga . . . described in the present report as the Moreno formation. . . . As the Tertiary shale of organic origin that occupies a similar stratigraphic position north of Coalinga is almost certainly the equivalent of the shale in the Kreyenhagen region it is described under the same name. It is noteworthy that a small body of siliceous shale of similar character and with little doubt of the same age is exposed in the Coalinga Westside field, a few miles northwest of the town of Coalinga, where it overlies the fossiliferous beds of the Tejon. This exposure forms a connecting link between the beds in the Kreyenhagen region and the correlated beds in the area mapped in the present report."

The contact between the Tejon and the overlying Kreyenhagen shale had previously been considered as apparently one of conformity. In this report by Anderson and Pack, however,

> "it is believed to be one of unconformity in most if not all of the region."

The evidence presented to uphold this belief may be summarized as follows: 1. The Tejon is lacking in a few areas, i.e., north of The Vallecitos, between Tumey Gulch and Panoche Creek, and north of Arroyo Hondo as well as between Ciervo Mountain and Tumey Gulch, where the Tejon thins perceptibly if it is not entirely absent, indicating an erosional break or lack of deposition. 2. The Tejon has a variable thickness

> "from 50 feet to over 750 feet through relatively short distances in the southern portion of the region and reaching a maximum of over 2000 feet in the northern portion."

3. That there is a

> "marked difference in the lithology of the beds comprised in the Tejon and in the Kreyenhagen when these formations are viewed as a whole and the difference in the faunas is suggestive of a break in sedimentation, although it must be admitted that this indication can not be given great weight in view of the sharp changes from detrital sediments to deposits of purely organic origin that take place within formations in this region."

It is needless to say that this is not very strong evidence in favor of a profound unconformity between the Tejon and the Kreyenhagen. Where the Tejon appears to be absent, the contact is not well exposed. Recent drilling by the Western Gulf Oil Company (Lillis-Welch well No. 1) encountered the Tejon (or Domengine) as a thin bed, over 30 feet thick in the Panoche region, where it was supposed to be absent. Furthermore, the evidence

> "is in part offset by the facts that the two formations appear everywhere conformable in dip, that in many places they seem to grade into each other, and that they are closely associated and almost co-extensive throughout this region and the Coalinga region to the south."

The Kreyenhagen shale, of this northern region, according to the authors is

> "roughly divisible into two parts. The lower part, comprising about two-thirds of the whole, is formed predominantly of clay shale, containing

diatoms and foraminifera, but not nearly so abundantly as the shale in the upper part. The lower part is dark brown when fresh, but weathers to a light chocolate color. The basal beds in much of this region are very sandy and appear to grade into the underlying Tejon. The upper third of the formation is largely soft diatomaceous shale weathering to rather massive pure-white outcrops."

South of Little Panoche Creek, along the foothills bordering the San Joaquin Valley, the exposed thickness of the Kreyenhagen was found to range from 600 to 1800 feet. Betweeen Little Panoche and Ortigalito creeks the maximum thickness is about 900 feet. Between Garzas and Little Salado creeks it is 750 feet. Here the shale is

"slightly more clayey and sandy than that exposed south of Ortigalito Creek, yet it is largly pure white and very diatomaceous, and forms prominent outcrops along the west side of the low hills between George Crow's ranch Crow Creek."

The relation of the Kreyenhagen shale to the occurrence of petroleum is of particular importance. The authors said:

"The shale is locally stained purplish by oil, and in a few places oil exudes from the beds in contact with it, but so far as known there are no considerable reservoirs of petroleum in it, the oil having migrated to the more porous overlying strata."

Although no very definite signs of oil occur in the exposed area of the foothill region, three oil seeps were reported from the Vallecitos as follows:

"in Mancillas Canyon, in the S½ Sec. 16., T. 17 S., R. 11 E.; in the canyon where the San Carlos well was drilled, in the S½ Sec. 8, T. 17 S., R. 11 E.; and 1½ miles farther northwest, in the SE¼ Sec. 6, T. 17 S., R. 11 E. The first two came from the upper middle part of the formation, and the third from beds near its top."

The Snelling well located near the San Carlos well reached a depth in 1912 of 800 feet in the Kreyenhagen shale and obtained small quantities of dark-greenish oil. An examination of it made by D. T. Day gave the following results:

Specific gravity at 60° F., 0.8850 (28.2° Baumé).
Distillation:

Begins to boil at 160° C.	Per cent
175°	2
200°	2
225°	9
250°	18
275°	9
300°	7
	47

Gasoline and naphtha, none.
Kerosene distillates, 47 per cent by volume.
Specific gravity, 0.8202 (40.7° Baumé).
Residuum, 53 per cent by volume.
Specific gravity, 0.9504 (17.3° Baumé).
Paraffin wax, none.
Hard asphalt, none.

"The composition of the residuum was not determined, but the oil is thought to be an 'asphalt oil' comparable in the main with the oil contained in the Miocene formations overlying the Kreyenhagen shale in the Coalinga district, although differing from that oil in certain interesting respects."

The oil found in such great quantity in the "Vaqueros" (Temblor) oil zone was regarded as originating from the Kreyenhagen shale. In addition to this oil

"some wells drilled in the Kreyenhagen shale near the Coalinga anticline have found indications of oil at several different horizons and certain wells obtained a small production from it. Among the producers were wells Nos. 2 and 3 of the Phoenix Oil Company, which started near the top of this formation in the SE¼ Sec. 20, T. 19 S., R. 15 E., and probably did not pene-

trate as far as its base. Well No. 3 is 560 feet deep and is said to have yielded for a time 50 barrels a day of heavy black oil variously reported to have had a specific gravity between 1.000 and 1.9459 (10° and 18° Baumé). Well No. 2 was drilled 380 feet deep and obtained similar oil in less quantity. Both were drilled most of the way through white shale interbedded with minor zones of dark shale and oil sand."

A relation between sandstone dikes and oil was described by Anderson and Pack, but nothing was mentioned as to the possibility that the dikes served as conduits for oil migration or that they might form local reservoirs for the accumulation of oil. The authors said:

"The sandstone dikes which are so prevalent in the formation from one end of the region to another may have been intruded into fractures in the shale by oil or gas under pressure, and their presence would thus be an indication that oil or gas once existed in these beds."

The presence of oil in the dikes, however, might just as well indicate its existence in the underlying source rock of the dikes.

1916

(20) Roy E. Dickerson, "Stratigraphy and fauna of the Tejon Eocene of California." *Univ. Cal. Publ., Bull. Dept. Geol. Sci.,* Vol. 9 (1916), pp. 363–524.

North of Coalinga (on the Lillis Ranch) the Domengine horizon was considered to be Tejon in age. The overlying diatomaceous shales (which were later mapped as Kreyenhagen shale by Robert Anderson and Pack) were tentatively divided into two groups as shown in a stratigraphic section modified after Dumble, as follows:

Oligocene	White shale. White fossil organic shales, containg fish scales, teeth, foraminifera, etc., 500 feet. Lenses of fine brown sand.
Tejon Eocene ?	White shales with local thin sandy strata, 1000 feet.

Dickerson showed a section (his figure 9, after Ruckman) made in the region of Domengine Canyon. He said (on page 462):

"Mr. John Ruckman found *Trochocyathus,* cf., *striatus* (Gabb) and *Crassatellites (Astarta) mathewsonii* (Gabb) in white shale beds immediately overlying the white Tejon sandstone in the Coalinga district near Domengine Creek. The coral is not definitely determinable, but it resembles *Trochocyathus striatus,* a characteristic form of the Tejon. The shales are somewhat ashy and they may represent reworked rhyolitic ash of the Sierra Nevada. The upper portion of these beds yielded Mr. Ruckman a small but characteristic fauna of Oligocene age, San Lorenzo stage. The Tejon fauna below the white shale is about equivalent to the Belanophyllia zone, Mount Diablo region, which is between that of the type Tejon and the Siphonalia sutterensis fauna. No other localities in which the uppermost zone of the Tejon is found are known in the Coast Ranges of California. Some residuals may be found, but apparently the uppermost strata of the Tejon were removed at least in large part during the great intervals of erosion between the Eocene and Oligocene, and Oligocene and Miocene."

The present writer has been unable to find this statement in Ruckman's unpublished thesis, and does not know where else these identifications are recorded.

In describing the Tejon group in the vicinity of Fort Tejon, Dickerson said (on page 418) that the basal Tejon conglomerates rest on granite rocks and associated schists. Those conglomerates are overlain by 1000 to 12,000 feet of thin-bedded brown sandstone with some clay shales, dark gray in color. In the sandstones some conglomerate layers are present and

"in one locality the dark grey pebbles of shale yielded a small pecten. The occurrence of this pecten suggests the deposition of Cretaceous deposits which were completely removed during upper Eocene time."

No suggestion was made as to the identity of this pecten. If this pecten is *Pecten interradiatus* as Anderson and Hanna (1925) have suggested, it would indicate the possibility of the shale pebbles being from the eroded Kreyenhagen rather than from the Martinez or Meganos (as those authors suggest).

(21) Bruce L. Clark, ''Meganos group, a newly recognized division in the Eocene of California.'' *Bull. Geol. Soc. Am.,* Vol. 29, (1916), pp. 281–296.

A series of beds, lying between the ''Tejon'' and the Martinez formations was recognized and given the name Meganos. An unconformity was said to exist between it and the overlying ''Tejon'' (Domengine). The formation north of Coalinga, formerly mapped as Martinez (?) by the United States Geological Survey was considered to be the Meganos formation. A series of chocolate shales was described in the lower part of the ''Tejon,'' associated with plant remains.

This Meganos formation of Clark's is now generally considered to be equivalent to the beds which F. M. Anderson called Kreyenhagen shale, north of Coalinga.

1918

(22) Walter A. English, ''Geology and oil prospects of the Salinas Valley-Parkfield area, California.'' *U. S. Geol. Survey, Bull. 691–h,* Part 2 (1918), pp. 226–227.

It is stated by English that in the area

> "neither the Tejon nor the Kreyenhagen formation crops out, nor are they believed to be present below the surface."

(23) Bruce L. Clark, ''The San Lorenzo series of Middle California.'' *Univ. Cal. Publ., Bull. Dept. Geol. Sci.,* Vol. 11 (1918), pp. 45–234.

It is stated in this report that John Ruckman collected fossils from the Kreyenhagen shale which showed conclusively that the formation is of Oligocene age. These fossils are in the collections of the Department of Geology of the University of California and include *Fusinus (Exilia) lincolnensis* (Weaver), *Macrocallista pittsburgensis* (Dall), and *Leda lincolnensis* (Weaver). Overlying the beds containing these three fossils are Miocene sandstones of the *Turritella ocoyana* zone.

In examining Ruckman's unpublished thesis (which is deposited in the Library of the University of California) the present writer found that these fossils were collected from the uppermost beds (Leda zone). Furthermore, in going into the field the same fossils (the *Macrocallista* and the *Leda,* but not the *Fusinus*) were found occurring exactly as originally described, but just beneath the narrow zone in which they are confined an unconformable contact was well exposed separating it from the rest of the mass of diatomaceous shales. The Leda zone is not extensive, though clearly exposed and grades into white tuff-sandstone, which is also fossiliferous and no doubt of the same age. The locality of this interesting fossil bed is in the Domengine Ranch, near the road which leads over the hills on which is exposed the Kreyenhagen shale.

In this same paper of Clark's were mentioned several other features of interest relative to the problem of the Kreyenhagen.

> "The San Lorenzo series of the region of Mount Diablo belongs to the same general period of deposition as the San Lorenzo formation of the Santa Cruz Mountains and the Kreyenhagen shales found along the west side of the San Joaquin Valley to the north and to the south of the town of Coalinga."

It was suggested that

> "the Oligocene of Mount Diablo is apparently not so old as the lowest Oligocene found in the San Emigdio Mountains."

The Concord, the Kirker, and the San Ramon or its stratigraphic equivalent, the Markley formation found in the Mount Diablo region, were considered to be Oligocene in age. It was suggested that the

> "narrow band of diatomaceous shale in the Markley formation represents the northward extension of the same conditions of sedimentation as those found farther to the south, i.e., during the period of deposition of the Kreyenhagen shales."

Lignitic shale and arkosic sandstone, above and below the diatomaceous shale north of Mount Diablo, show that the depositional trough was shallower to the north than in the south.

> "The shale of this horizon varies from a chocolate color to almost a pure white; some of the layers, especially near the base, are rather thick and massive; higher up they are thinner-bedded and in places form typical paper shale. Marine diatoms are abundant in the lower beds, the genus *Coscinodiscus* being the most common form."

A stratigraphic section of the Markley formation on the north side of Mount Diablo is given by Clark as follows:

(Overlain by the tuffaceous sandstones of the Kirker formation and separated by a disconformity)

500 feet—Micaceous, gray to yellow-brown sandstones and shales, the latter variegated in color.
160 feet—Light-colored shales, diatomaceous in part.
300 feet—Dark, carbonaceous, arenaceous and argillaceous shales.
1400 feet—Micaceous sandstones and argillaceous and arenaceous shales alternating; poor outcrops of shale.
200 feet—Soft, argillaceous shale.
700 feet—Medium-coarse, gray, arkosic, micaceous sandstones.

(Beneath lies Tejon shale 500 feet thick)

This "Tejon shale" overlies the "Tejon" (Domengine) sandstone. The

> "lower two thousand feet of the Markley formation is unfossiliferous. These beds are apparently conformable with the Eocene deposits below and with the fossiliferous Oligocene above; therefore the period to which they belong might be open to question."

In an earlier publication Clark (1912) "included these lower beds in the Tejon," while the diatomaceous shales were referred to as Monterey. It was stated that

> "the following molluscan species were obtained from the diatomaceous, light-colored shales of the Markley formation: *Acila muta, Leda pulchrosinuosa, Malletia packardi, Pecten alterlineata* and *Yoldia* species."

At the old and abandoned coal mine of Nortonville, the Eocene (Domengine) sandstone (containing coal beds) is exposed. Above it occurs a series of chocolate-colored shale with some beds of soft sandstone, which appeared to the writer, during a field investigation, to resemble the basal beds of the Kreyenhagen shale. Furthermore, the upper diatomaceous shales of the Markley are similar to the upper diatomite beds of the Kreyenhagen, the so-called *Pecten peckhami* zone. Examination of the microscopic fauna and flora has recently confirmed this correlation. The whole formation, from the top of the Domengine to the base of the Kirker tuff, therefore, would appear to be equivalent to the entire Kreyenhagen shale. Above the Markley, however, Clark believes that a disconformity is evident, indicated

largely by the boulder content of the basal Kirker. The fossils of the Kirker (according to Clark) bear out its Oligocene age. The tuff beds of the Kirker are not unlike those of the tuff beds in the *"Leda zone"* of Domengine Canyon with a like fauna. We may, therefore, tentatively place the Markley as equivalent to the Kreyenhagen and Kirker to the Leda zone.

1920

(24) R. W. Pack, "The Sunset-Midway oil field, California." Part I. Geology and oil resources. *U. S. Geol. Survey, Prof. Paper 116* (1920), pp. 25–26, pl. 2.

Although the Oligocene beds were recognized by Pack, he did not separate them from the "Vaqueros," mapping the two formations as one unit. In a correlation table, the Kreyenhagen shale of previous reports is placed equivalent to the lower part of the Vaqueros-Oligocene formation of his report, but in describing the Tejon formation, he said:

> "Most of the Tejon that crops out east of the creek, in the north flank of the Devil's Kitchen syncline, is composed of sandy shale that weathers to chocolate-brown. This shale supports little vegetation other than a few scattered groups of juniper trees. In general aspect it resembles the more clayey phases of the later Tertiary diatomaceous shale in this region or the Kreyenhagen and Moreno shales in the Coalinga region."

The Eocene shale, according to Pack, is not present on Salt Creek, but crops out between Pleito and San Emigdio creeks, as a greenish black to chocolate-brown clay shale. Its position is in the uppermost part of the Tejon and its absence in places was explained by the presence of the unconformity which occurs between the Tejon and the overlying Vaqueros-Oligocene formation of sandstones.

Clark (1926) in describing the Domengine sandstone, said that it lies beneath the Tejon on San Emigdio creek and separated from it by unconformity. It is difficult to say just what the relationship is between the shale above described and Clark's Domengine formation.

1921

(25) Walter A. English, "Geology and petroleum resources of northwestern Kern County, California." *U. S. Geol. Survey, Bull. 721* (1921), pp. 12–13, pl. I, II.

English mapped two areas of questionable Oligocene west of Wagonwheel Mountain, in the region of Devils Den. He described the formation as "Pink to brown clay shale and diatomaceous shale". He followed the mapping of Arnold and Johnson, though with some modifications." He thought that the fossils found in the formation were "not diagnostic of any particular horizon"; that the top reef bed of the Vaqueros was equivalent of that of Devilwater Creek farther south, and that the questionable Oligocene might be "the equivalent of the underlying part of the undifferentiated Vaqueros and Maricopa deposits," which he showed in a stratigraphic correlation chart of sections northwest of McKittrick.

As a result of the present writer's investigation some 750 feet of Kreyenhagen shale similar to the type on Reef Ridge was found at the base of the Wagonwheel Mountain section. A series of shale and sand stone (carrying fossils similar to those of the base of the type San Emigdio formation) lies above the Kreyenhagen shale and below the

"Vaqueros" or Temblor. An unconformity separates this series from the Miocene.

(26) Bruce L. Clark, "The marine Tertiary of the West Coast of the United States: its sequence, paleontology, and the problems of correlation." *Jour. Geol.* Vol. 29 (1921), pp. 585–614.

Epochs in the Oligocene are recognized as the Lower Oligocene (Lincoln horizon) and the Upper Oligocene (San Lorenzo horizon). The Kreyenhagen shales are placed in the lower division and it is shown that the deepest trough of deposition was along the western border of the San Joaquin Valley.

1922

(27) Walter Stalder, "The Ciervo anticlinal bow oil field of California," *Eng. and Min. Jour.*, Vol. 113, No. 10 (March 11, 1922), pp. 409–413, 6 figs., incl. geol. map.

The name Kreyenhagen was used in the same sense that Robert Anderson and Pack used it.

(28) H. O. Elftman, "A geologic reconnaissance of a portion of the eastern flank of the Diablo Range in Stanislaus and Merced counties, California." *Unpublished thesis* for A. B. degree at University of California (1922?).

Elftman discovered a few fossils in the formation mapped by Robert Anderson and Pack as "undifferentiated Miocene." These fossils indicated that the formation should possibly be correlated with Clark's Kirker formation. Among the fossils were found: *Acila muta, Pecten peckhami, Thyasia* sp., and plant impressions. This formation is bounded by an unconformity above (overlain by the San Pablo formation), and an unconformity below (underlain by the white diatomite beds of the Kreyenhagen). The formation attains a thickness of 450 feet. It was locally referred to as the Newman sandstone.

Underlying the Kirker (?) formation unconformably and overlying Eocene sandstone (apparently conformably) is the Kreyenhagen shale. This is largely a diatomite, white on the surface, but brownish on fresh fracture. The basal part of the formation contains interbedded sandstones, gray, arkosic, and containing muscovite. The diatomite is traversed by sandstone dikes originating from the interbedded sandstone.

A few fossils such as *Pecten peckhami, Acila* cf. *muta,* fish scales, and fish vertebra were found in the Kreyenhagen diatomite. It is the same *Pecten peckhami* horizon as found in the region farther south, and furthermore the micro-fauna have recently proved this conclusively.

The interbedded sandstone of the Kreyenhagen appears to be the equivalent of the Markley sandstone, described by Clark farther to the north. It is barren of fossils. Its contact with the underlying Eocene fossiliferous sandstone was not actually seen.

1923

(29) C. M. Wagner, and K. H. Schilling, "The San Lorenzo group of the San Emigdio region, California." *Univ. Cal. Publ., Bull. Dept. Geol. Sci.,* Vol. 14 (1923), pp. 235–276.

The series was divided into two formations, the San Emigdio, forming the lower half, and the Pleito, the upper, both carrying fossils in

abundance. In the San Emigdio, three horizons were recognized; a lower massive sandstone, a middle dark-colored shale, and an upper sandstone. The two lowest, together, are about 300 feet thick, while the upper is 700 feet. The maximum thickness of the Pleito is recorded as being 2300 feet, with a thin basal conglomerate, followed by massive sandstones, shales and sandy shales, again sandstones and grits, and finally local conglomerates at the top. The group as a whole is correlated with the San Lorenzo of Oregon and Washington.

Two fossils, *Phacoides inflata* W. & Sch. and *Thyasira folgeri* W. & Sch., are abundant in the dark shale and sandy beds, which lie above the barren basal sandstone beds of the San Emigdio formation. These two fossils were also found by the present writer in abundance in the sandstone bed that overlies the Kreyenhagen shale proper west of Wagonwheel Mountain, Devils Den, suggesting a local correlation of this horizon in the two localities.

West of the San Emigdio Canyon, chocolate-colored shale, occurring on Muddy Creek, were considered by Wagner and Schilling probably to be contemporaneous with the lower shale of the San Emigdio member of the formation.

The Tejon Eocene, of the upper end of San Emigdio Canyon, is not very fossiliferous, though 2000 feet thick. Although the lower part of the formation in this locality is coarse and sandy, it is on the whole rather shaly, containing brown shales, dark, greenish, and yellow with sandy material interbedded. This lack of fossils is a very peculiar condition to consider since the type Tejon, lying only twelve miles to the east, contains fossil shells in great abundance, especially in its upper layers.

1924

(30) R. D. Reed, "Role of heavy minerals in the Coalinga Tertiary formations." *Econ. Geology,* Vol. 19 (1924), pp. 730–749.

Although the Kreyenhagen shale was apparently found to be devoid of pebbles and sparingly supplied with heavy minerals, the data secured by Reed led him to reach the conclusion that the source of the deposited detritus consisted of Cretaceous rocks and not Franciscan, as was the case with the much later Santa Margarita diatomite. The organic contents of the Kreyenhagen shale were of pelagic origin and were deposited in a "land-lockt sea, depth unknown." The climate at the time of deposition was probably tropical. The period ended with "emergence and local folding."

1925

(31) F. M. Anderson, and G. D. Hanna, "Fauna and stratigraphic relations of the Tejon Eocene at the type locality in Kern County, California." *Cal. Acad. Sci.,* Vol. 11 (1925).

A general stratigraphic section is given for the Tejon formation on Live Oak Creek as follows:

600 feet or more, sandy shales weathering to a yellowish-gray color, forming rounded slopes. (The uppermost beds.)
300 feet, dark carbonaceous shales, thin-bedded.
650 feet, alternating sands and shales, dull gray in color.
1200 feet, rusty-colored sands, distinctly bedded, and sandy shales with concretionary layers.
250 feet, basal conglomerates, and coarse sands, not well exposed.

The only part of this section which appeared to the present writer possibly to resemble slightly the Kreyenhagen shale is the dark carbonaceous clay shale, red-purple to chocolate-brown in color, that occurs near the top of the series. Unfortunately, no micro-organisms were found in it to serve as a basis for comparison. It is barely possible that the stratigraphic horizon of the lowest part of the Kreyenhagen shale is equivalent to the horizon of this clay shale.

In commenting on Dickerson's paper (1916), Anderson and Hanna refer to a small pecten which he found in the shale pebbles of the basal conglomerate of the type Tejon. The authors stated that the pebbles of shale ''may as readily be taken as evidence of the unconformity of the Tejon Group upon older Eocene strata,'' as for ''Cretaceous deposits which were completely removed during Eocene time.'' Small pectens such as *Pecten interradiatus* occur ''in both the Martinez and the Meganos Groups.''

The identity of the pecten was not given by Dickerson, but should it be the pecten mentioned, why should not the lower beds of the Kreyenhagen shale be considered as its source?

(32) G. D. Hanna, ''Data on the age and correlation of the Kreyenhagen shale in Fresno County, California.'' *Petroleum Age,* Vol. 10 (December 1925), pp. 60, 78–80.

(33) G. D. Hanna, ''The age and correlation of the Kreyenhagen shale in California.'' *Bull. Am. Assoc. Petroleum Geol.,* Vol. 9 (1925), pp. 990–999.

In this publication, Hanna did not accept the correlation recognized by the Federal Survey that the type Kreyenhagen shale on Reef Ridge, south of Coalinga, is represented by the diatomaceous shale lying immediately beneath the Lower Miocene sandstones north of Coalinga. Instead, he referred back to the original report by F. M. Anderson, that the Eocene shale which lies beneath the so-called Tejon or Domengine sandstone, north of Coalinga, is the same as the type Kreyenhagen shale on Reef Ridge, which lies upon Tejon or Avenal sandstone. He apparently did not consider the Domengine and the Avenal to be of the same age. He thus concluded that the Kreyenhagen was of Eocene age. Reasoning in this manner, the name Kreyenhagen applied by Robert Anderson and Pack for the shale above the Domengine, should not have been given, for

> "the bulk of the evidence thus far seen indicates that it belongs to the Miocene period of deposition"

rather than to the Oligocene and certainly not Eocene. These upper diatomaceous shales were considered as being either absent or overlapped in the region of the type locally of the true Kreyenhagen on Reef Ridge.

This paper of Hanna's, it can readily be understood, started a controversy at once among geologists. Although the conclusion reached, that the Kreyenhagen of the type locality is of Eocene age, may be correct, the steps taken to prove that it may be correlated with the lower shale exposed north of Coalinga would appear to be incorrect. Hanna said that paleontologic proof was offered by Arnold and Robert Anderson (in their bulletins of the Coalinga district) that the Kreyen-

hagen shales of Reef Ridge are of Eocene age, by the occurrence of "*Orbitolites* sp." which undoubtedly is *Orthophragmina clarki* Cushman. This species of foraminifera was collected, however, not in the Kreyenhagen shale, but in the underlying Eocene sandstone "lower member," as it is recorded.

For the reason that he considered the shale north of Coalinga, lying beneath the "Tejon" or Domengine sandstone, as Kreyenhagen, Hanna came to the conclusion that the Domengine sandstone is entirely missing at the type locality on Canoas Creek. In the Government reports, the sandstone (Avenal) lying beneath the "upper member," or Kreyenhagen shale of Canoas Creek, and the sandstone mapped as the Tejon (Domengine) north of Coalinga were considered the same formation.

Hanna also questioned the identification and value as horizon markers of the three molluscs which Clark employed to place the Kreyenhagen in the Oligocene. These fossils, however, were found by the present writer to occur in beds unconformably overlying the Kreyenhagen.

There would certainly be "no contesting the Eocene age" of the Kreyenhagen shale if its name is applied to the Eocene shales which F. M. Anderson originally described north of Coalinga as Kreyenhagen shale.

1926

(34) George M. Cunningham, "The Wheeler Ridge oil field." *Bull. Am. Assoc. Petrol. Geol.,* Vol. 10 (1926), pp. 495–501.

In the area cornered by townships 10 and 11 north and ranges 20 and 21 west, a shale phase of the "Vaqueros" was referred to the Oligocene. It was described as being composed almost entirely

> "of dark gray to nearly black clay shale which weathers to a chocolate-colored soil."

(35) G. C. Gester, "Observations relating to the origin and accumulation of oil in California." *Bull. Am. Assoc. Petro. Geol.,* Vol. 10 (1926), p. 894, fig. 1.

Gester showed that the only commercially important Oligocene source rocks for oil in California occur in the Coalinga fields, while the only commercially important Oligocene reservoir rocks are those of Ventura and Newhall districts (where the source is assigned to the Eocene). By the Oligocene of Coalinga, however, he meant the Kreyenhagen shale.

(36) Bruce L. Clark, "The Domengine horizon, Middle Eocene of California." *Univ. Cal. Publ. Bull., Dept. Geol. Sci.,* Vol. 16 (1926), pp. 99–118.

The sandstone previously mapped north of Coalinga by the U. S. Geological Survey as Tejon, underlying Kreyenhagen shale and overlying the Martinez (?) formation was regarded by Clark as earlier in age than Tejon and was referred to by him as the Domengine sandstone.

Clark correlated the Kreyenhagen shale with the Markley formation of the Mount Diablo region.

1927

(37) G. D. Hanna, "The lowest known Tertiary diatoms in California." *Jour. Paleon.,* Vol. 1 (1927) pp. 103–126.

Fifty-two different species of diatoms are described from the diatomaceous shales (*Pecten peckhami* horizon) occurring north of Coalinga and previously mapped by Robert Anderson and Pack as the Kreyenhagen shale; thirteen are new.

Hanna considered the age of the organic beds as Lower Miocene, and that the Kreyenhagen shale of F. M. Anderson lies below, in the Eocene. The reasons given for assigning the age are as follows: (1) That

> "some of the mollusks mentioned, as well as others collected at the same place, appear to be identical with forms found in Lower Miocene deposits elsewhere in the west, and about which there has never been doubt as to age."

(2) That

> "*Pecten peckhami* Gabb, so common in California Miocene shales, is abundant near the middle of the formation and several hundred feet directly under the place where the other mollusks mentioned were found."

(3) That abundant diatoms found associated with these pectens and elsewhere along the strike of the beds,

> "are most closely allied to the flora of shales found higher up in the Miocene section but still far below the actual top. There is also frequent identity of species here and in some formations elsewhere which have always been referred to the Lower Miocene particularly the deposits of Maryland, New Jersey, and Virginia."

(38) M. G. Wilmarth, "Tentative correlation chart of geologic formations in Pacific border of California south of San Francisco. California chart I (of 4 sheets)." *U. S. Geol. Survey* (not yet published) (January, 1927).

In this chart the Kreyenhagen shale is placed questionably in the lower part of the Oligocene. It is also shown to overlie by a questionable unconformity the Tejon formation. The thickness is recorded as 600–1800 feet. The formation north of Coalinga, as described by Robert Anderson and Pack, is considered the type and F. M. Anderson's classification of the shale is not mentioned.

The only equivalent formation shown is that of the Butano sandstone. It "may be Eocene," according to this correlation table.

(39) J. A. Taff, and G. D. Hanna, "A geologic section in the center of the San Joaquin Valley, California." *Cal. Acad. Sci., 4th Ser.*, Vol. 16 (1927) No. 16, pp. 509–515.

Three deep wells drilled by the Associated Oil Company in the flat plain of the San Joaquin Valley, southwest of Fresno, give some data on the possibility of finding Kreyenhagen shale in this alluvial covered area, for definite Eocene rocks were recognized in all three wells, which reached depths of 6042, 6884, and 5737 feet respectively. Their locations are as follows:

(A) Sec. 26, T. 15, R. 18
(B) Sec. 14, T. 15, R. 18
(C) Sec. 35, T. 13, R. 16

(A) Between Vaqueros sands and Eocene sands, 150 feet of "undifferentiated clay shales" were passed through.

(B) Between questionable Vaqueros sands and foraminiferal Eocene shales, three series of beds are recorded: First, 206 feet of "undifferentiated clay shales." Second, 120 feet of "undifferentiated con-

glomerates and sands probably the base of the Miocene.'' Third, 662 feet of ''undifferentiated sands and clays, probably Eocene.''

(C) Between the ''Big Blue'' Miocene and the Eocene sands, 201 feet of ''Lower Miocene diatomaceous shales'' were drilled through. It is quite possible that this diatomaceous shale may be correlated with the Kreyenhagen shale as described by Robert Anderson and Pack, but the shale has ''not yet been definitely identified'' with that formation.

It is a notable fact that no great thickness of Kreyenhagen shale, if any at all, appears in any of these wells.

(40) Gerard Henny, ''Some notes on the geology of the south San Joaquin Valley, California.'' *Bull. Am. Assoc. Petrol. Geol.*, Vol. 11 (1927), p. 612.

> "Geological Survey maps show Kreyenhagen shales, referred to the Oligocene, but it is probable that these beds are of Eocene rather than Oligocene age, since a bed in the middle of the Kreyenhagen shales near Wagonwheel Mountain, southwest of the Devils Den region contains numerous specimens of a *Corbis* similar to *Corbis diegoensis* Dickerson in the Domengine (Eocene) formation of the San Emigdio Mountains."

This sandstone bed, however, lies on top and not in the middle of the Kreyenhagen shale proper, although beneath other similar-appearing shales. The ''*Corbis diegoensis*'' referred to, is similar to *Phacoides inflata* Wagner and Schilling of the type San Emigdio formation found in a sandstone bed near its base. In both localities (San Emigdio Canyon and Wagonwheel Mountain) this fossil is associated with *Thyasira folgeri* W. & Sch., which is probably the young form of *Thyasira bisecta* Conrad.

(41) Bruce Clark, and A. O. Woodford, ''The geology and paleontology of the type section of the Meganos formation (Lower Middle Eocene) of California.'' *Univ. Cal. Publ., Bull. Dept. Geol. Sci.*, Vol. 17 (1927), pp. 63–142.

It is shown that the four divisions of the marine Eocene in the Coast Ranges of California (i.e. Martinez, Meganos, Domengine, and Tejon) are not all represented in the Mount Diablo region, the Tejon being absent. The following question is raised, however,

> "might it not be that the lower arkosic sandstones of the Markley are referable to the Tejon?"

But since fossils are lacking in these beds, this question is left unanswered, though in a recent meeting of the Cordilleran Section of the Geological Society of America, the answer was given in the affirmative, based on a collection of Tejon fossils obtained in the Potrero Hills, on the north side of San Francisco Bay, but not at the type locality of the Markley. In an earlier publication, Clark correlated the Kreyenhagen shale with the Markley formation of the Mount Diablo region, and the Markley was thus considered to be Oligocene.

The Markley formation is said to have a thickness of over 3000 feet,

> "a great series of deposits of arkosic sandstones and dark lignitic clay shales."

The basal beds

> "appear to be conformable with upper shales of the Domengine formation. The division between the two was made because of the sharp change in lithology."

(42) Hubert G. Schenck, ''Marine Oligocene of Oregon.'' *Univ. Cal. Publ., Bull. Dept. Geol. Sci.*, Vol. 16 (1927), p. 458.

The Bassendorf shale is stated to have a thickness of 1900 feet and to be foraminiferal and diatomaceous. Its type locality is given as follows: Bassendorf Beach, Sec. 3, T. 26 S., R. 16 W., Oregon. It is reminded that Dall suggested the equivalence of this shale to F. M. Anderson's Kreyenhagen shale north of Coalinga, California. This last mentioned shale, where Anderson got his foraminifera, is, however, true Eocene, lying below the Domengine. It is not the type Kreyenhagen shale found south of Coalinga on Reef Ridge, nor the white shale group mapped as Kreyenhagen north of Coalinga.

(43) C. F. Tolman, "Biogenesis of hydrocarbons by diatoms," *Econ. Geol.*, Vol. 22 (1927), pp. 454–474.

In a

> "summary of data presented at the symposium on the organic siliceous shales, Geological Society of America, Cordilleran Section, Jan. 29, 1926,"

R. N. Nelson stated that

> "the most important diatomaceous shale deposits of California occur in the Tertiary. The earliest of these is the Kreyenhagen shale considered by some to be Oligocene and by others Eocene in age. Exposures of this shale are found on the western side of the San Joaquin Valley from San Emigdio, at the extreme south, to the north side of Mt. Diablo, at the north. The shale has a thickness of from 400 to over 1000 feet at Coalinga. On the north side of Mt. Diablo it is 500 feet thick."

A paper by Robert Anderson summarized and reaffirmed the theory

> "that most of the oil in California originates in the shales characterized by remains of minute organisms, chiefly diatoms and foraminifera."

The Kreyenhagen was said to be of Oligocene age and not of the Monterey group. The Kreyenhagen shale was shown to be one of

> "at least four distinct formations of this type of Plankton shale, representing different periods of deposition, but each showing a petroliferous character, and standing in a position of mother rock for larger accumulations of oil."

(44) J. A. Cushman, and G. D. Hanna, "Foraminifera from the Eocene near Coalinga, California." *Cal. Acad. Sci.*, Vol. 16, No. 8 (1927), pp. 205–229.

From a locality several miles north of Coalinga, a collection of foraminifera was made by Hanna from

> "a section across the Eocene exposure southeast of the old camp of 'Oil City,' NW¼ Sec. 20, T. 19 S., R. 15."

The specimens came from

> "a few feet above the sandstone reef to several hundred feet below and into muddy shales and the organisms in them are so distributed that it appears we are dealing with one formational unit."

The foraminiferal sandy shales a "few feet above the sandstone" lie just below the contact (apparently a disconformity) of the chocolate-colored shales, mapped by Robert Anderson and Pack as the Kreyenhagen. The present writer examined it and found the bed described.

It was pointed out by the authors, Cushman and Hanna, the latter being responsible for the work on stratigraphy, that the name Kreyenhagen was applied by F. M. Anderson to the muddy shales of Canoas Creek, with which the lower Eocene muddy shales north of Coalinga were correlated. Although Robert Anderson and Pack later said this correlation was in error, Hanna took exception to the correction, basing his argument largely on the occurrence of one important diagnostic Eocene foram, *Orthophragmina clarki* (Cushman).

Hanna points out that this same foraminifera was figured by Arnold and Johnson as coming from Reef Ridge, north of McClure Valley (Sec. 27, T. 23 S., R. 17 E.).

> "This locality can hardly be other than an extension of the exposure southward from the type locality of the Kreyenhagen shale."

It is described in these earlier reports as "*Orbitolites* sp." and as having come from the "lower member" of the Eocene. This "lower member," as it has been explained by the authors and by Robert Anderson and Pack, refers to the fossiliferous sandstone of the Eocene and not to the "upper shale member," which is the Kreyenhagen shale.

None of the 33 species of the foraminifera of the collection came from the Kreyenhagen proper. They are clearly diagnostic of the Eocene. Their stratigraphic positions are given as 10 feet above the sandstone, 100 feet below, 200 feet below, and several hundred feet below. The upper horizon is very close to the contact with the Kreyenhagen shale proper but not in it.

(45) H. G. Schenck, "Review No. 541 (Cushman and Hanna, 'Foraminifera from the Eocene near Coalinga,' *Proc. Cal. Acad. Sci., Ser. 4,* Vol. 16, pp. 205–229, pls. 13–14)" Revue de Geologie, VIII^me annee, fasc. 4 (1927), p. 250.

Schenck criticized the stratigraphic portion of the paper (prepared by Hanna) as an

> "exhumation of a problem carefully considered by Robert Anderson and R. W. Pack in 1915 * * * Hanna's contention is that the Kreyenhagen shale at its type locality is Eocene, and not Oligocene as most geologists believe. He apparently follows Frank M. Anderson in correlating the Kreyenhagen at the type locality where it overlies Eocene sandstone, with shales below Eocene sandstone at a locality several miles farther north. In the absence of more evidence than here adduced, this opinion is not convincing. * * * Many determined species are reported to occur also in the lower Oligocene and upper Eocene of the Gulf Coastal Plain of the United States and Mexico."

The foraminifera, however, collected by Hanna, came from true Eocene beds, which lie below the brown shales of the Kreyenhagen of Robert Anderson and Pack. Apparently Schenck did not realize this and in later papers indicated that the uppermost bed collected by Hanna north of Coalinga might be within the Kreyenhagen shale. Schenck correlated Hanna's material with the Bassendorf shale of Oregon and considered it as Lower Oligocene. Hanna's material, however, came from beds distinctly Eocene. This feature is very clear and has been checked in the field.

1928

(46) J. A. Cushman and H. G. Schenck, "Two foraminiferal faunules from the Oregon Tertiary," *Univ. Cal. Publ., Bull. Dept. Geol. Sci.,* Vol. 17 (1928), pp. 305–324.

The Bassendorf and Keasey shales of Oregon are

> "tentatively regarded as lower Oligocene in age, because of their position between sandstone correlated with Tejon Eocene and another sandstone carrying a molluscan fauna that may be correlated with similar faunas in formations in California that lie above Tejon Eocene and below Vaqueros Miocene."

Through the occurrence of representatives of four genera of foraminifera *(Cristellaria, Cyclammina, Pulvinulina, and Polymorphina),* Dall had previously indicated the similarity of this Bassendorf shale

to F. M. Anderson's Kreyenhagen shale (1905) of the locality north of Coalinga. But Anderson's description of the shale north of Coalinga was in reference to the true Eocene shales and not to those mapped as Kreyenhagen by Robert Anderson and Pack.

In consideration of the previous report by Cushman and Hanna (1927), Schenck (who was largely responsible for the stratigraphic work of above joint Oregon paper by Cushman and Schenck) criticized the assignment to the Eocene of the collections from north of Coalinga rather than to the Oligocene and sent out the warning

> "that paleontologists should carefully note the exact stratigraphic position of all specimens described by Cushman and Hanna before drawing any conclusions regarding correlations."

Discocyclina (Orthophragmina) clarki (Cushman), a typical Eocene foraminifera, was said to be found only below the sandstone, i. e., the Eocene sandstone known by the names Domengine and Tejon. (But the fact is, that it occurs within the standstone and in beds immediately below the contact of the Kreyenhagen shale proper; the present writer and others have collected it there.) It is said that the foraminifera common to the two localities in Oregon and California, occur for the most part "ten feet above the sandstone." (But this zone is stratigraphically a part of the Eocene series and not of the chocolate shale series which lies above, mapped by Robert Anderson and Pack as Kreyenhagen.)

(47) Hubert G. Schenck, "Stratigraphic relations of western Oregon Oligocene formations," *Univ. Cal. Publ., Bull. Dept. Geol. Sci.*, vol. 18 (1928), p. 18.

The Oligocene of Oregon is divided into three stages (Lower, Middle, and Upper) and the Bassendorf shale is placed in Lower Oligocene. It is shown that the Bassendorf shale is diatomaceous and foraminiferal.

In other publications, Schenck suggested that the Bassendorf shale may be correlated with the Kreyenhagen shale of California, but this was done by comparison of the fauna with that of some beds (which are actually Eocene) that lie immediately under the diatomaceous Kreyenhagen shale of Robert Anderson and Pack.

1929

(48) Hubert G. Schenck, "Discocyclina in California," *Trans. San Diego Soc. Nat. Hist.*, vol. 5, No. 14 (1929), pp. 211–240.

The name *Discocyclina* has been replaced by Orthophragmina. Although upper Eocene beds carry at least ten species of this genus

> "no species is known from unquestioned Oligocene strata."

The present writer has found abundant specimens of *Discocyclina clarki* immediately under the Kreyenhagen shale proper in the region of its type locality and in the region north of Coalinga.

(49) Bruce L. Clark, "Tectonics of the Valle Grande of California." *Bull. Am. Assoc. Petrol Geologists*, vol. 13, No. 3 (1929), pp. 213–215, fig. 4.

The Kreyenhagen shale is said to be well represented in the Wagonwheel Mountain section, but is apparently not present in any of the sections in the Temblor Mountains. On a map the Kreyenhagen shale is shown to be underlain by the Domengine sandstone, with one excep-

tion, i. e., on the southern flank of the Vallecitos syncline, where the Meganos formation is shown to lie beneath.

(50) Bruce L. Clark, "Stratigraphy and faunal horizons of the coast ranges of California, with illustrations of index fossils of Tertiary horizons." *Publication privately issued.* (Received June 25, 1929), pp. 17–18.

The upper part of the Kreyenhagen, as mapped by Robert Anderson and Pack, is considered by Clark to be Oligocene, belonging to the Lincoln horizon of that period.

(51) G. Dallas Hanna, "Micro-organisms of the marine siliceous shales of California," *paper read before the Pacific Coast Section, American Assoc. of Petrol Geologists* (Nov. 22, 1929).

In this paper Hanna showed that the silico-flagellates of the same shales from which he previously had collected diatoms, and tentatively correlated with the Miocene, indicate an Eocene age rather than a Miocene.

(52) H. G. Schenck, "Miocene brown shale of the Kettleman Hills, California," *paper read before the Pacific Coast Section, American Assoc. of Petrol Geologists* (Nov. 22, 1929).

In the general discussion of the shales of the district, Schenck said that type Kreyenhagen shale did not contain recognizable diatoms, but instead great numbers of radiolaria. In consideration of the Kreyenhagen shale as a source rock for oil, Schenck said that we should look for a source other than diatoms for the oil of the Kreyenhagen.

1930

Symposium on the Stratigraphic and Faunal Relationships Between the Eocene and Oligocene of the Great Valley of California.

This symposium was arranged by the Cordilleran Section of the Geological Society of America at the 29th annual meeting, University of California, Feb. 21, 1930. (Abstracts republished without alteration of name *Cantua* to *Lillis*, and without including the whole of F. M. Anderson's abstract, in *Pan-Am. Geologist*, Vol. LIV, No. 1 (August 1930), pp. 77–80.)

(53) F. M. Anderson, "The Kreyenhagen shale and the Cantua Shale." (The name Cantua was changed for Lillis.)

The name Lillis shale was proposed as a substitute for the name Kreyenhagen as used by Robert Anderson and Pack. The upper part of the type Kreyenhagen on Canoas Creek was admitted to be the Lillis shale, but a lower horizon, containing a foraminiferal zone was correlated with the Eocene shale below the Domengine sandstone north of Coalinga. The Avenal sandstone was said to be Meganos in age. The Kreyenhagen, as Anderson defined it, is equivalent to the shale mapped by the government north of Coalinga as Martinez (?). The Kreyenhagen shale, thus defined, would be Eocene, while the Lillis was considered Miocene in age.

(54) Olaf P. Jenkins, "Stratigraphic problem of the Kreyenhagen shale, California."

The results given were practically the same as those now presented.

(55) Bruce L. Clark, "The stratigraphic relationships in the Mt. Diablo area of the Upper Eocene deposits to those of the Oligocene."

"The discovery by Dr. Thomas Bailey of well preserved Tejon fauna from a series of beds in the Potrero Hills, which beds have a similar lithology and stratigraphic position to those of the Markley formation of the type section north of Mt. Diablo, makes it very probable that the age determination of the Markley by B. L. Clark as being Oligocene is incorrect but that it is the equivalent to the Tejon (Upper Eocene) of other parts of the state. The unconformity which was described as coming between the Markley formation and the Kirker is apparently the break between the Eocene and Oligocene of that area.

"The invertebrate fauna of the lower beds of the Kirker formation has been correlated with that of the Lincoln horizon of the Oligocene. This correlation is still believed to be correct. This fauna in the Kirker is equivalent to that which was found a number of years ago from the uppermost Kreyenhagen shales north of Coalinga."

(56) Thomas Bailey, ''The Eocene age of the Markley formation.''

If the formation described is actually equivalent to the type Markley, then the age of the Kreyenhagen shale, or at least its lower portion, should be of Tejon. The collection of Tejon fossils described was found in the Potrero Hills, north of Suisun Bay, and was thought to be equivalent to the Markley.

(57) Charles E. Weaver, ''Stratigraphic relations of the Domengine and Markley formations in the Antioch, Vacaville and Napa quadrangles.''

The Markley micaceous sandstones are massive, and attain a thickness of 3000 feet. They rest in apparent conformity upon the Domengine (100 to 300 feet thick) and both formations contain marine molluscan fossils. The Markley formation contains, characteristically, tuff beds near the base and top.

(58) C. C. Church, ''Foraminifera of the Cantua shale.'' (The name Cantua is changed to Lillis.)

This paper gave the results of a study of the foraminifera collected from the upper white shales of the Markley formation and of the Kreyenhagen shale as mapped by the government, but called Lillis shale in this paper. The fauna was shown to be quite new and distinct. No ties were found to connect it with Eocene, Oligocene, or Miocene, though Church favored correlating it with the Miocene rather than the Eocene. A correlation was made with a certain shale reached in one of the wells drilled by the Associated Oil Company near the center of the San Joaquin Valley (Herminghaus Well No. 1, located in sec. 35, T. 13 S., R. 16 E.). An abundance of the same forms was found in this brown shale at a depth of 4877–4885 feet. The formation extended down to 4973 feet. Underlying this formation, with apparent unconformity, was found the Eocene.

(59) G. Dallas Hanna, ''Silicoflagellates from the Cantua shale.'' (The name Cantua is changed to Lillis.)

Eight common species of silicoflagellates were recognized in the white shales of the Kreyenhagen which Hanna called in this paper, the Lillis. Only two of these species extend to the Monterey formation. Several other species were correlated with diatom deposits of Barbados Island and of Jutland, Denmark, which may be Miocene or Eocene. Assignment of a definite age to the shale would depend upon European correlation.

(60) G. Dallas Hanna, ''Diatoms from the Cantua shale.'' (The name Cantua is changed to Lillis.)

Hanna was fairly certain that the diatoms of the Lillis shale (upper part of the Kreyenhagen) show the age to be equivalent to that of the

celebrated deposit on Barbados Island. The age of the latter, however, is in some doubt, though placed by Nuttall as equivalent to the Naparima clays of Trinidad, which are Lower Miocene in age.

(61) Olaf P. Jenkins, ''Sandstone dikes as conduits for oil migration through shales,'' *Bull. Am. Assoc. Petrol Geologists,* Vol. 14, No. 4 (April, 1930), pp. 411–421.

The name Kreyenhagen was used in the same sense that Robert Anderson and Pack used it. Intrusive bodies of sandstones (''intruclasts'') occurring abundantly in this formation as well as in other shale bodies, are considered to have served as conduits for permitting fluids and gases to be transferred from one underground reservoir to another.

(62) Olaf P. Jenkins, ''A study of the Kreyenhagen shale: stratigraphy, character, mode of formation, structure, extent, probable age, and economic aspects,'' *Stanford Univ. Bull.,* 5th ser., No. 98 (July 31, 1930), Abstracts of Dissertations.

The thesis of which this abstract was written has formed the basis of the writer's present paper.

(63) W. P. Woodring, ''Upper Eocene Orbitoid Foraminifera from western Santa Ynez Range, California, and their stratigraphic significance,'' *Trans. San Diego Soc. Nat. Hist.*, Vol. VI, No. 4 (1930), p. 160.

It is indicated that at least part of the type San Emigdio and Pleito formations of the southern end of the San Joaquin Valley may ''embrace beds of upper Eocene age.''

(64) H. W. Hoots, ''Geology and oil resources along the southern border of San Joaquin Valley, California,'' *U. S. Geol. Survey, Bull. 812–D* (1930), p. 251.

No mention is made of correlation with the Kreyenhagen shale. It is stated that

> "The lithology of the upper part of the Tejon formation in San Emigdio Canyon differs from that of the overlying San Lorenzo formation (Oligocene) in that it is comparatively thin-bedded throughout, with no unusually massive beds of sandstone, and that shale is the preponderant type of rock."

(65) D. Dale Condit, ''Age of the Kreyenhagen shale in Cantua Creek-Panoche Creek district, California,'' *Jour. Paleontology,* Vol. 4, No. 3 (September, 1930), pp. 259–262.

Condit divides the Kreyenhagen into four horizons (''A,'' ''B,'' ''C,'' and ''D''), ''D'' being the lowest, which may now be correlated with the writer's Kreyenhagen shale proper. ''C'' horizon is an intermediate sandstone. ''B'' horizon was found by the present writer to have a clearly defined unconformity running through the middle of it, leaving the upper part, plus the ''A'' horizon, as the Leda zone, formerly referred to, which is a distinct formation of about 100 feet thick, containing a molluscan fauna of either Miocene or Oligocene age. The lower part of ''B'' horizon is a diatomite, with apparent similarity to the upper beds of ''D'' horizon. Anderson and Pack (1915) previously mapped the ''C'' horizon as ''Vaqueros,'' indicating a fault line between ''C'' and ''B.'' In the ''C'' horizon the writer found specimens of *Thyasira folgeri* W. & Sch., and suggests correlation with the so-called Oligocene sandstone beds lying above the Kreyenhagen shale proper near Devil's Den. These sandstones may possibly be correlated with the lower beds of the type San Emigdio formation.

(66) Fritz E. Von Estorff, "Kreyenhagen shale at the type locality, Fresno County, California," *Bull. Am. Assoc. Petroleum Geologists,* Vol. 14, No. 10 (October, 1930), pp. 1321–1336.

Of the 27 foraminifera listed by Von Estorff only two have been given specific names and one of these, not definitely. In the four columns (headed I, II, III, and IV), "I" only came from very near Canoas Creek (the locality generally conceded to be the type), and under this column are listed eight genera (none of which are diagnostic of definite age). Collections listed in the other three columns came from the sandy clay shale or "transitional zone," underlying the Kreyenhagen shale proper, as regarded by the writer, who is inclined to place the foraminiferal beds with the known Eocene, or Avenal formation. In this locality *Pecten interradiatus* is found in the foraminiferal sandy shales (as well as above them in the Kreyenhagen shale proper) in the same manner as it is found north of Coalinga.

(67) Thomas L. Bailey, "The geology of the Potrero Hills and Vacaville region, Solano County, California," *Univ. Calif. Publ. Bull. Geol. Sci.,* Vol. 19, No. 15 (1930), pp. 322, 326–327, pl. 39.

On account of

> "the discovery of the Tejon fossils in the upper part of the so-called Markley formation on the south side of the Potrero Hills",

north of San Francisco Bay, Bailey maps the formation as Tejon. This is not at the type locality of the Markley and can not be traced to it on the surface. The type

> "Markley formation had failed to yield any determinable fossils, heretofore, but had been tentatively placed as Oligocene by Clark".

(68) Bruce L. Clark, "Tectonics of the Coast Ranges of Middle California," *Bull. Geol. Soc. Am.*, Vol. 41, (1930), pp. 760, Pl. 15.

In this paper the Kreyenhagen shale is placed in the Eocene and correlated with the Tejon formation. Clark says:

> "In 1917 John Ruckman, than a graduate student at the University of California, discovered several well preserved fossils in the upper portion of the Kreyenhagen shales north of Coalinga on the Domengine ranch. These included three typical Lincoln species, *Macrocallista pittsburgensis* Dall, *Leda washingtonensis* Weaver and *Exilia lincolnensis* Weaver, none of which had been found in the Eocene or Miocene. The writer, in his paper on the San Lorenzo series of middle California, on the basis of this fauna tentatively placed all the Kreyenhagen shales as Oligocene.
>
> "O. P. Jenkins has since shown that these upper beds, which contain the Lincoln fauna, lie unconformably on the shales below. This upper Oligocene formation forms only a small part of the original Kreyenhagen shales of that section. Therefore, the name 'Kreyenhagen shales' should be retained for the lower shales, and either the beds above the unconformity should be given a new name or possibly the name 'Kirker,' the Oligocene formation north of Mount Diablo, should be applied to them. The Oligocene deposits are separated from those of the Temblor formation above by a marked structural unconformity.
>
> "In the light of the recent discovery by Thomas Bailey of a well preserved Tejon (upper Eocene) fauna in the upper portion of the Markley formation, as exposed in the Potrero Hills north of Suisun Bay, not only must the Markley formation of the Mount Diablo section be placed in the Eocene instead of in the Oligocene, as the writer had previously placed it, but also this makes it probable that the Kreyenhagen shales of the Coalinga area are upper Eocene in age. Work on the microsocopic faunas of these shales will undoubtedly throw more light on the problem."

(Figure 1.)

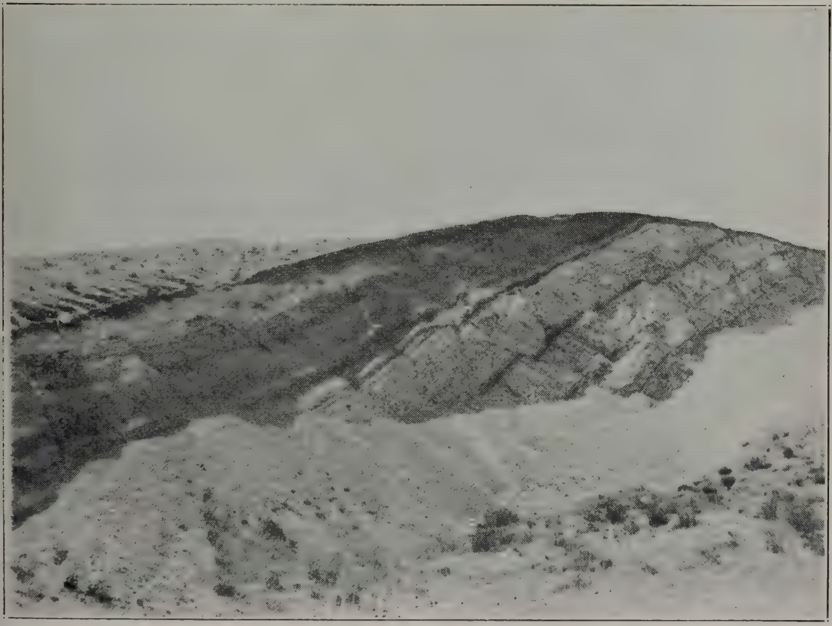
Looking southeastward along Reef Ridge across Big Tar Canyon. Left, Temblor reef; right, Avenal reef; both of sandstone, Miocene and Eocene, respectively. Depression between the two, occupied by Kreyenhagen shale. Extreme right, Cretaceous shale and sandstone, unconformably underlying Avenal sandstone. All formations plunge beneath Kettleman Hills (extreme left, 15 miles distant) and San Joaquin Valley beyond. *(Photo by F. von Estorff.)*

(Figure 2.)

Looking northwestward from Ragged Valley road, Domengine Ranch, north of Coalinga. Diatomite beds of Kreyenhagen shale (as mapped by U. S. G. S. Bull. 603). Right, upper beds of formation, white on exposure. Left, lower beds, brownish and more cherty, also petroliferous in places. *(Photo by F. von Estorff.)*

(Figure 3.)

Looking northwestward from Ragged Valley road (one-half mile west of Fig. 2) towards topographic depression occupied by lower brown shales of the Kreyenhagen (U. S. G. S.). Extreme right, upper white diatomite beds. Left, type "Domijean" or Domengine sandstone (Eocene). Underlying, extreme left, foraminiferal sandy shales of the "Martinez?" (U. S. G. S.) or Meganos of Clark, or Kreyenhagen of F. M. Anderson. *(Photo by F. von Estorff.)*



(Figure 4.)

Unconformable contact between Kreyenhagen white diatomite (*Pecten peckhami* horizon) and darker colored "Leda zone" above, lowest bed of which is gravelly with *Pholas* borings extending into white shales below. Looking southeastward towards Ragged Valley road, Domengine Ranch.

(Figure 5.)

Vertical beds, showing contact between sandy "Leda zone" (right) and lower white diatomite (left). *Pholas* borings into diatomite (at contact where hammer head is placed) are proof of unconformity (besides angularity seen elsewhere). Location, north of Arroyo Ciervo, where these diatomite beds lie above sandstone horizon "C" of Condit, but formerly mapped as Kreyenhagen shale by U. S. G. S.

(Figure 6.)

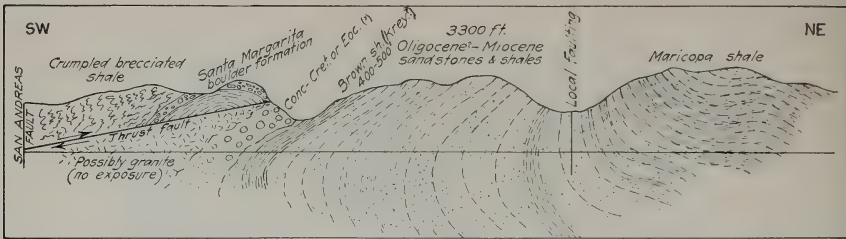
Contact (unconformity), upper part of "Leda zone" (limy rock to right, Condit's horizon "A') with Temblor conglomeratic sandstone lying above, left. Hammer head on lateritic peaty material of old surface. Location, north of Arroyo Ciervo.

(Figure 7.)

Contact, sandstone of Condit's "C" horizon with white diatomite of Kreyenhagen shale below. Sandstone (apparently intrusive in part) cuts across and stringers from it intrude diatomite, so that original nature of the sedimentary contact is obliterated. Sandstone was originally mapped as "Vaqueros" by U. S. G. S., Bull. 603, and a fault was indicated between it and diatomite of Fig. 5. Location, north of Arroyo Ciervo.

(Figure 8.)

Contact, Kreyenhagen diatomaceous shale with overlying sandstone of Condit's "C' horizon (formerly mapped by U. S. G. S. as "Vaqueros"). Location, Tumey Gulch. Small intruded dikes and fragments of sandstone occur in diatomite below, but main body of sandstone is bedded, conglomeratic, and contains broken fragments of fossils.



(Figure 9.)

Diagrammatic section across area south of Elkhorn plain, 5 miles southwest of Maricopa, illustrating position of brown, indurated shale, thought by the writer to be Kreyenhagen. (See columnar section No. 12, figures 10 and 11.) The writer's interpretation of the structure serves also to explain a possible source of the huge granite boulders found in the over-thrusted Santa Margarita formation.

(Figure 10.)

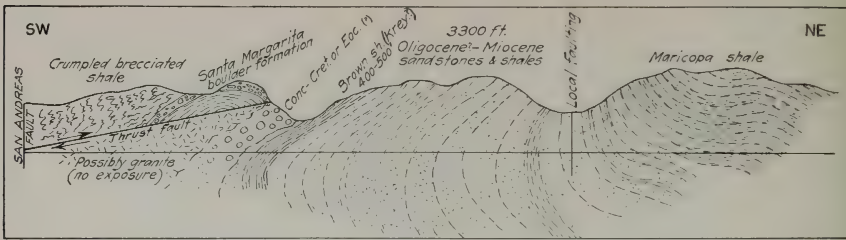
Index map of a central part of California showing:

Locations of columnar sections by *numbers.*

Exposures of Kreyenhagen shale in *black.*

Area (in San Joaquin Valley) probably underlain by Kreyenhagen shale, ruled with *vertical lines.*

Areas containing sandstone equivalents of the Kreyenhagen shale, *stippled.*



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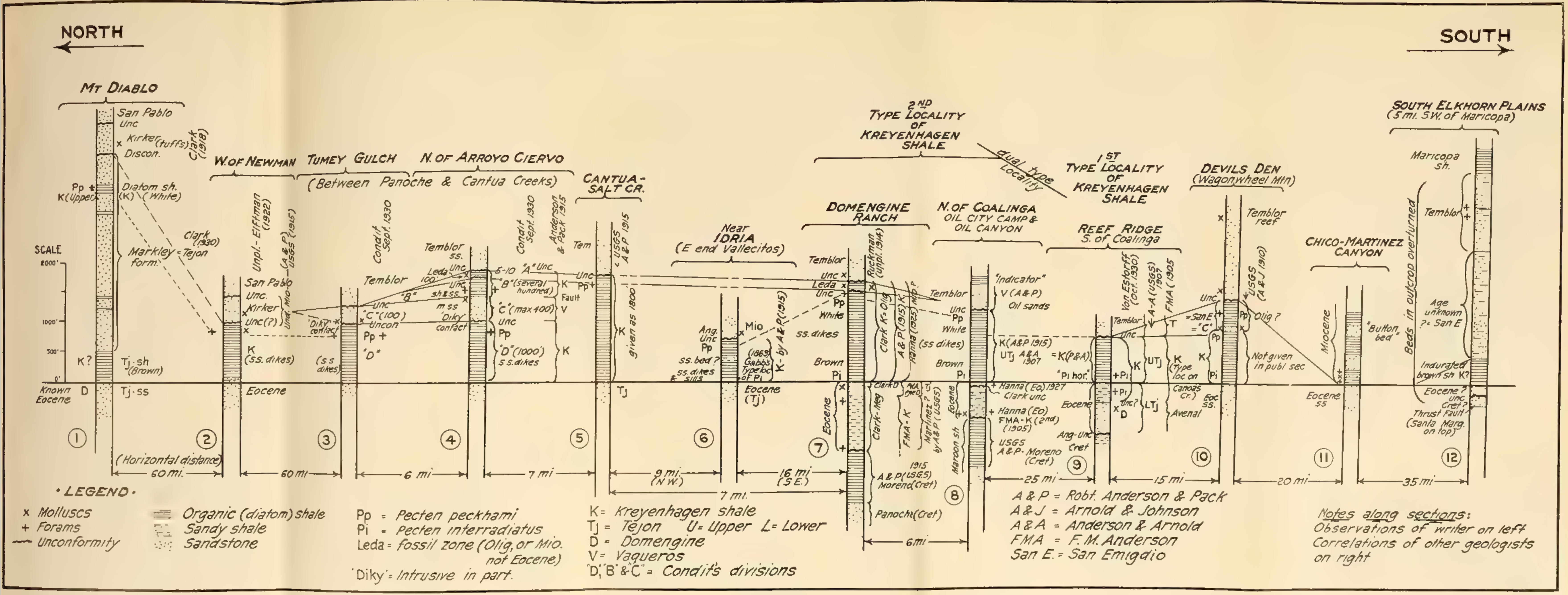

(Figure 11.)

Correlation chart of twelve local columnar sections, each prepared from detailed study of significant regions lying in the foothills of the western side of the San Joaquin Valley. (For locations see figure 10.) The object of this chart is to clarify, in a graphic manner, the various usages of stratigraphic terms previously employed, and to present the writer's own interpretation of their correlation.

DIATOMS AND SILICOFLAGELLATES OF THE KREYENHAGEN SHALE

By G. D. Hanna.*

INTRODUCTION

In accordance with the definition of the Kreyenhagen shale given by Olaf P. Jenkins in the foregoing pages, the following general statements pertaining to the paleontology are offered with confidence. Limiting the name to the siliceous shales which lie between the unconformity above and the clay shales and sandstones of definitely Eocene age below will aid materially in stabilizing the nomenclature. Although no well-marked unconformity has been found at this lower contact, the change is marked by an overwhelming displacement of such of the fauna and flora as have been preserved. The prolific assemblages of Eocene mollusca ceased to exist and the foraminifera which dominated the seas of that period in the San Joaquin Valley region disappeared, their places being taken by different forms.

Radiolaria, Silicoflagellata and Diatomaceae were almost nonexistent in the Eocene seas of this region up to the period of transition if we may judge from the fossil material thus far found. When the change began these groups appeared and, while a few scores of feet of sediment were being deposited, they came to dominate the waters. These groups continued to thrive thereafter, while a maximum thickness of 1800 feet was accumulating. Much of the material was organic debris, the skeletal remains of members of the three groups mentioned.

So profound a change in the inhabitants of the ocean at that time must have been induced by some cataclysm of more than secondary importance. An examination of the fossils gives a clue to what may have happened. A very large proportion of these were organisms which lived in the open sea. Such pelagic accumulations gather in present oceans only in water of very considerable depth. It is reasonable to assume that a similar condition existed during the Kreyenhagen.

In contrast, the Eocene fauna immediately below is of relatively shallow-water habitat. Many of the forms could not exist far below the tide line.

The inference from this is that there was a very pronounced subsidence during the Kreyenhagen period. The sediments themselves bear out this supposition. The Eocene beds are composed largely of detrital materials derived from weathered land areas. The nonorganic constituents of the Kreyenhagen are usually extremely finely-disseminated particles. In many cases, these are of uncertain derivation, but in a few instances they have been identified as volcanic ash.

AGE OF THE KREYENHAGEN SHALE

The exact position of the shale in the geologic column is difficult to determine. This is not because of scarcity of paleontological materials

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but may be ascribed to the newness of attempting to apply the fossils concerned to the purpose in hand. Not enough stratigraphic work has been done on similar deposits elsewhere in the world. In attempting to determine the age, however, critical comparison of the diatoms and silicoflagellates has been made with material from practically all of the known Tertiary deposits which contain these organisms in noticeable numbers. The Radiolaria have not yet been used, although enough has been learned to lead to the belief that they will confirm the conclusions reached from the other groups.

A deposit on the island of Mors, Denmark, and another in Jutland, contain a very considerable number of species, identical or closely similar to those of the Kreyenhagen. The resemblance is too great to permit much discrepancy in age. Moreover, the forms referred to are not found in higher or lower formations in California or elsewhere.

European geologists in general, refer the Danish deposits to the Eocene and unless they be mistaken in the determination, which is improbable, the Kreyenhagen likewise should be Eocene. Some of the critical species concerned are illustrated herewith. Complete identity of faunas and floras would not be expected on geographic grounds and there is likewise probably a difference in the portion of the Eocene to which the two localities belong. The Jutland deposit is often referred to as lower Eocene while if the Kreyenhagen be Eocene at all, it must have accumulated near the end of the epoch.

Stratigraphically, the formation is more closely related to the Eocene than to the overlying formations, as Jenkins has pointed out. Proof that it is Tejon is lacking, direct or indirect.

It has been suggested that the Kreyenhagen may be the western equivalent of some formations called Oligocene elsewhere, and the possibility of this being true must be admitted. Unfortunately we have no diatoms and silicoflagellates for comparison from undoubted Oligocene elsewhere.

The celebrated oceanic deposit on Barbados Island requires consideration in this connection because it contains some noteworthy species of diatoms which are likewise found in the Kreyenhagen. This similarity is sufficient to warrant the suggestion (at one time) that the formations are contemporaneous. This was before the Danish deposits had been critically compared and before it was learned that there is some uncertainty regarding the age of the Barbados material. The latest determination appears to have been "Miocene" but the paleontological evidence for the determination was somewhat meager. It has been shifted from one epoch to another almost as much as the Kreyenhagen and until much more work has been done, it is believed that the Barbados deposit must remain of somewhat doubtful age.

One objection to placing the Kreyenhagen in the Eocene is that a very insignificant thickness of strata is left between it and Temblor Miocene above to represent the Oligocene. Another is that the Kreyenhagen lacks orbitoid foraminifera which are usually present in both Eocene and supposed Oligocene. Much more evidence is needed on these points before definite conclusions can be drawn. The positive

evidence we have, points to an Eocene age for at least the lower portion of the formation and although more facts are needed for a final assignment, temporary reference to that epoch seems warranted on paleontological grounds.

There is a possibility which is far from remote that the Kreyenhagen as a whole represents the greater part of the interval between Eocene and Miocene and that the basal and topmost beds of the formation are of these ages, respectively. This theory is strengthened by the failure to find a good basal unconformity and the character of the unconformity at the top. Where the formation is developed to its maximum thickness, this upper unconformity is readily discernible but it would seem that it should be much more profound if it represented all or the greater part of, Oligocene, and some of the lower Miocene. Moreover, the difference in the assemblages of diatoms and silicoflagellates above and below the shale on shale contact, while apparent, is far from being extreme. It would seem that if a very great time interval were represented by the break, more pronounced differences would appear than have thus far been found.

In conclusion, regarding the age of the Kreyenhagen, it seems necessary to leave the matter somewhat doubtful until more study has been given to deposits elsewhere which have similar lithology and paleontology. The bulk of the evidence thus far assembled favors the Eocene, but there is a possibility that it extends upward into later periods.

Only three mollusks have been found in the formation; *Pecten interradiatus* near the base, *Pecten peckhami* (?) near the top and a *Nucula (Acila)* found with the latter in a limited area. The first two are fairly useful for zonal mapping but afford no certain clue as to age. The *Nucula* has not been critically studied.

ORGANIC CONTENT AND OIL GENERATING POSSIBILITIES

The Kreyenhagen is often referred to as a siliceous shale because silica forms a major constituent. The shales are usually thinly laminated and banded. On casual inspection they appear identical to shales of Cretaceous, lower, middle and upper Miocene, and Pliocene age. This similarity has caused much confusion, but paleontologically all of these may be readily distinguished.

Much of the silica present is of organic origin. When unmodified by chemical metamorphism, the material is properly classified as a diatomite. Compared with similar material of other ages which has been analyzed, it is estimated that some of the Kreyenhagen sections contain hundreds of feet of 75 to 90 per cent pure organic, unmodified silica. The diatoms, of course, predominate in such cases, and radiolaria come next with sponges and silicoflagellates present to a lesser degree.

These diatomites can be traced through several stages of metamorphism; loose, light, fluffy material; partially-compacted shale with well-preserved organisms; partially-cemented but porous shale with only the impressions of organisms left; and finally dense opal and flint. These modifications occur within such short distances along the strike

and cross the dip that it may be assumed that the formation was originally organic debris to a large extent. Such fossils are quite unstable in alkaline solutions, a fact which can be readily demonstrated in the laboratory.

The diatoms of the great mass of the formation are such forms as normally thrive floating in the open sea. These are exemplified by such genera as *Pterotheca, Stephanopyxis* and *Hemiaulus.* Toward the base of the formation, more attached or bottom-dwelling species appear, such as *Arachnoidiscus, Aulacodiscus* and heavier forms of *Coscinodiscus.* The outcrop in the quarry near Antioch contains a better representation of such forms than do many of the outcrops farther south.

Fortunately, certain extremely common species are not found in any of the diatomites of other age in California; they, therefore, afford an easy means of determination of the shale. The same is true of the silicoflagellates. These organisms are very reliable for this purpose. They never appear so abundantly as the diatoms and comparatively few species are present in any one formation. Nevertheless, they are structurally so distinct that they can readily be found in most cases. The Kreyenhagen is particularly characterized by a long slender form with a spine at each end. Certain triangular species are likewise important and can be found in all samples of Kreyenhagen thus far studied after a very brief search.

Most of the Kreyenhagen shale is stained various shades of brown from almost black to light buff. Boiling in sulphuric acid and other chemicals shows the coloring matter to be hydrocarbons. Some of these are volatile and exposure to the atmosphere allows them to escape, leaving a brilliant white shale. Others are more in the nature of a tar residue but all bear a definite relationship to petroleum and none to carbonaceous higher-plant debris. It seems most improbable that so great an amount of hydrocarbon could have been generated elsewhere and reached the Kreyenhagen by migration. It is much more plausible to believe that the volatile materials were generated in the shale itself. This theory is strengthened by the presence of large amounts of petroleum in porous sandy beds immediately overlying the Kreyenhagen in favorable structures such as east Coalinga and Kettleman Hills.

As to the particular organisms which produced the basic compounds responsible for the oil, the diatoms seem to be the most suitable. In a living condition each individual contains one or more globules of oil and it is possible that this enters into the formation of petroleum. It is also highly probable that the remainder of the contents of these plants, except the silica, is utilized in the generation of hydrocarbons. Otherwise, some residues of a nonhydrocarbon nature would be expected in the diatomites and they do not occur. The presence of salts found in ocean water may be necessary as catalysts or otherwise; at any rate, none of the large accumulations of freshwater lake diatoms have produced a noticeable amount of petroleum. It is highly improbable that all of the oil at a given locality was produced from a single group of organisms but in the case of the California diatomites, no

other forms than the diatoms are present in sufficient abundance to have been of much aid.

The specimens illustrated in the accompanying plates have been deposited in the California Academy of Sciences.

EXPLANATION OF PLATE A

Fig.

1. *Xanthiopyxis specticularis* Hanna. Holotype (No. 3006, C.A.S.) from Loc. 894. Length, 0.0562 mm.; width, 0.0253 mm.

2. *Metrosulus petrolia* (Hanna). Holotype (No. 3024, C.A.S.) from Loc. 894. Length, 0.0254 mm.; width, 0.019 mm. This form was described as a *Biddulphia.*

3. *Hemiaulus claviger* Schmidt. Plesiotype (No. 3053, C.A.S.) from Loc. 894 Length, 0.10 mm.; width, 0.044 mm.

4, 5. *Trochosira trochlea* Hanna. Holotype (No. 3050, C.A.S.) from Loc. 894. Diameter, 0.030 mm.; parts of one individual.

6. *Hemiaulus polymorphus* Grunow. Plesiotype (No. 3015, C.A.S.) from Loc. 894. Height, 0.030 mm.; width, 0.0284 mm.

7, 8, 9. *Liradiscus ovalis* Greville. Plesiotypes (Nos. 3021–3023, C.A.S.) from Loc. 894. Length (fig. 8), 0.060 mm.; width, 0.0451 mm.; others enlarged to same scale.

10, 11. *Pterotheca danica* Grunow. Plesiotypes (Nos. 3331, 3332, C.A.S.) from Loc. 1832. Length (fig. 10), 0.067 mm.; width, 0.0424 mm.; fig. 11 enlarged to same scale.

12. *Pterotheca carinifera* Grunow. Plesiotype (No. 3333, C.A.S.) from Loc. 1832. Length, 0.069 mm.; width, 0.0234 mm.

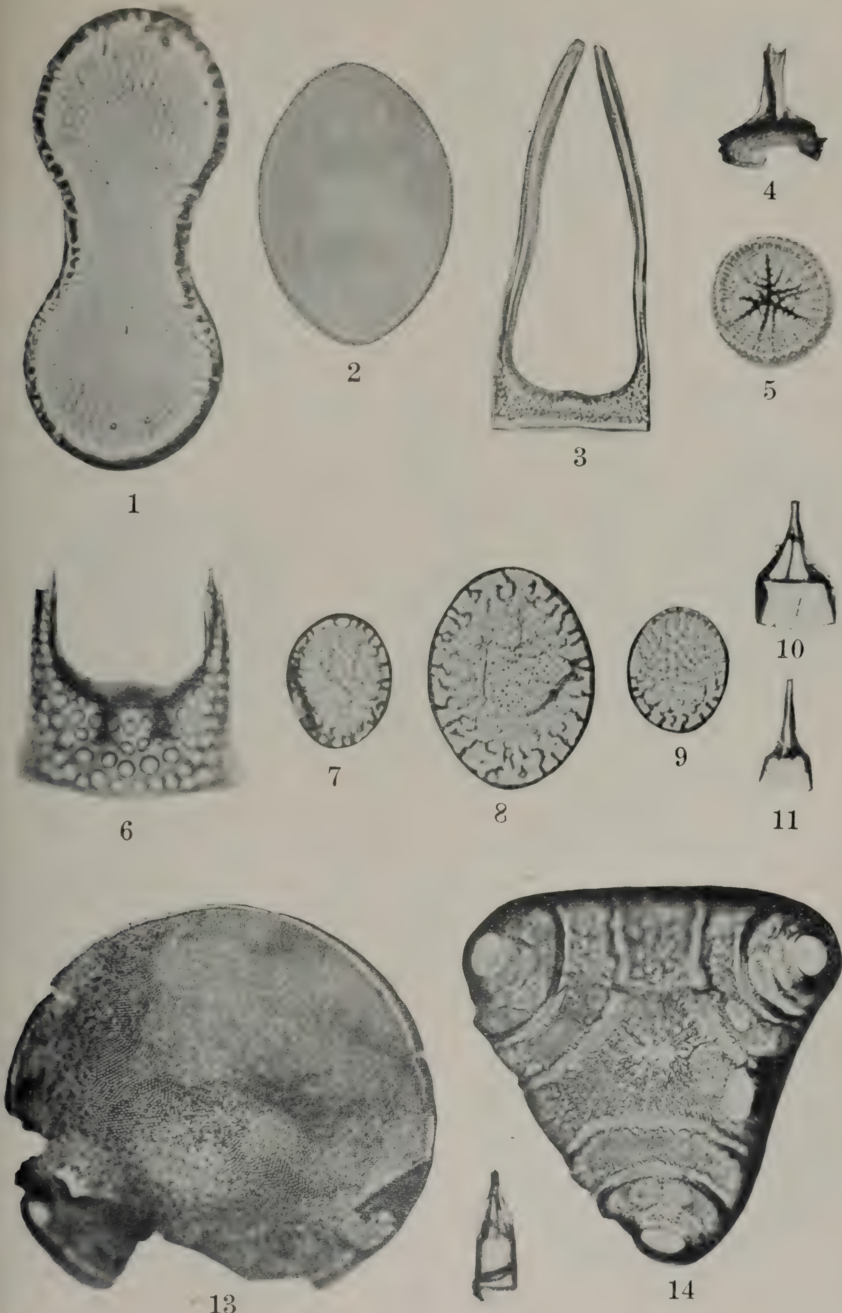
13. *Coscinodiscus symbolophorus* Grunow. Plesiotype (No. 3317, C.A.S.) from Loc. 1832. Diameter, 0.160 mm.

14. *Triceratium lineatum* Greville. Plesiotype (No. 3343, C.A.S.) from Loc. 1832. Length of upper side, 0.082 mm.

Loc. No. 894, Calif. Acad. Sci., Sec. 20, T. 19 S., R. 15 E., M.D.M.; Phoenix Canyon, a small branch of Oil Canyon, about seven miles north of Coalinga, Fresno County, California. Kreyenhagen shale. G. D. Hanna, Coll., January, 1924. The collection came from about 100 feet below the top of the formation near a prominent talus slope which reaches the creek bottom.

Loc. No. 1832, Calif. Acad. Sci., NE¼, Sec. 2, T. 1 N., R. 1 E., M.D.M., 2½ miles south of Antioch, Contra Costa County, California. Kreyenhagen shale. C. C. Church, G. D. Hanna, O. P. Jenkins and J. A. Taff, Colls., January, 1930. The collection came from an abandoned quarry which appeared to be located well toward the base of the diatom-bearing shales.

Cal. State Div. of Mines Hanna, Plate A



DIATOMS OF THE KREYENHAGEN SHALE.

EXPLANATION OF PLATE B.

Fig.

1, 2. *Craspedodiscus oblongus* (Greville). Plesiotypes (Nos. 3322, 3323, C.A.S.) from Loc. 1832. Length (fig. 1), 0.0690 mm.; width, 0.030 mm.; length (fig. 2), 0.080 mm.; width, 0.0378 mm.

3. *Coscinodiscus subnitidus* Rattray. Plesiotype (No. 3319, C.A.S.) from Loc. 1832. Diameter, 0.0576 mm.

4. *Stephanopyxis corona* Ehrenberg. Plesiotype (No. 3339, C.A.S.) from Loc. 1832. Diameter, 0.050 mm.

5. *Arachnoidiscus indicus* Ehrenberg. Plesiotype (No. 3310, C.A.S.) from Loc. 1832. Diameter, 0.0672 mm.

6, 7. *Pyxilla intermedia* Tempere & Forti. Plesiotypes (Nos. 3334, 3335, C.A.S.) from Loc. 1832. Length (fig. 6), 0.10 mm.; width, 0.0380 mm.; length (fig. 7), 0.0960 mm.; width, 0.0270 mm.

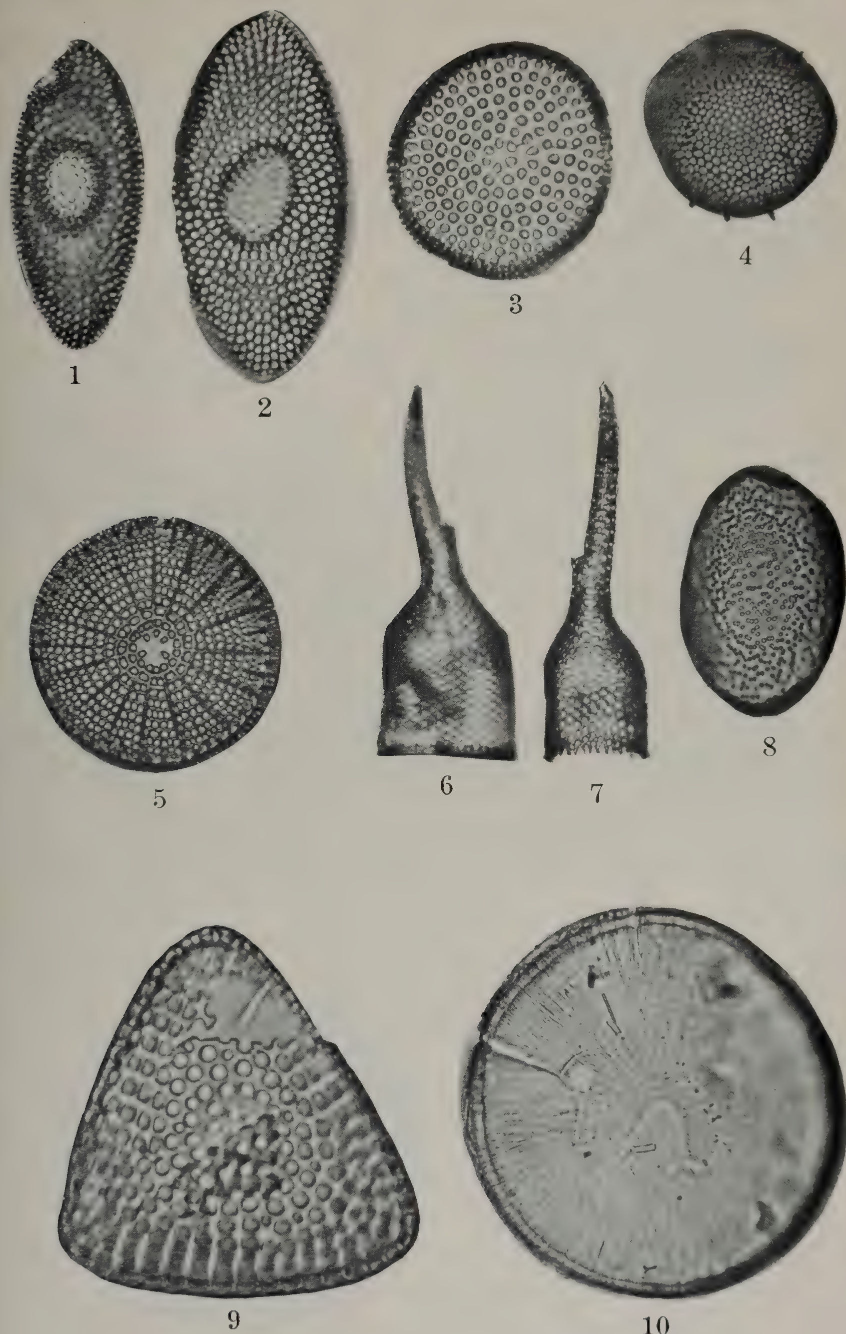
8. *Xanthiopyxis* (species?) Plesiotype (No. 3344, C.A.S.) from Loc. 1832. Length, 0.0538 mm.; width, 0.036 mm.

9. *Stictodiscus coalingensis* Hanna. Plesiotype (No. 3341, C.A.S.) from Loc. 1832. Length of lower side, 0.0457 mm.

10. *Ethmodiscus* (species?). Plesiotype (No. 3348, C.A.S.) from Loc. 1832. Diameter, 0.0504 mm.

Loc. 1832, Calif. Acad. Sci., NE¼, Sec. 2, T. 1 N., R. 1 E., M.D.M.; 2½ miles south of Antioch, Contra Costa County, California. Kreyenhagen shale. C. C. Church, G. D. Hanna, O. P. Jenkins and J. A. Taff, Colls., January, 1930. The collection came from an abandoned quarry which appeared to be located well toward the base of the diatom-bearing shales.

Cal. State Div. of Mines - Hanna, Plate B.



DIATOMS OF THE KREYENHAGEN SHALE.

EXPLANATION OF PLATE C.

Fig.

1, 2. *Roperia marginata* Hanna, n.sp. Holotype and paratype (Nos. 3336, 3337, C.A.S.) from Loc. 1832. Diameter (fig. 1), 0.0656 mm.; (fig. 2), 0.120 mm.

3, 5. *Rattrayella californica* Hanna, n.sp. Paratypes (Nos. 3305, 3306, C.A.S.) from Loc. 1832. Diameter (fig. 3), 0.0591 mm.; (fig. 5), 0.040 mm.

4. *Rattrayella californica* Hanna, n.sp. Holotype (No. 3304, C.A.S.) from Loc. 2256. Diameter, 0.0369 mm.

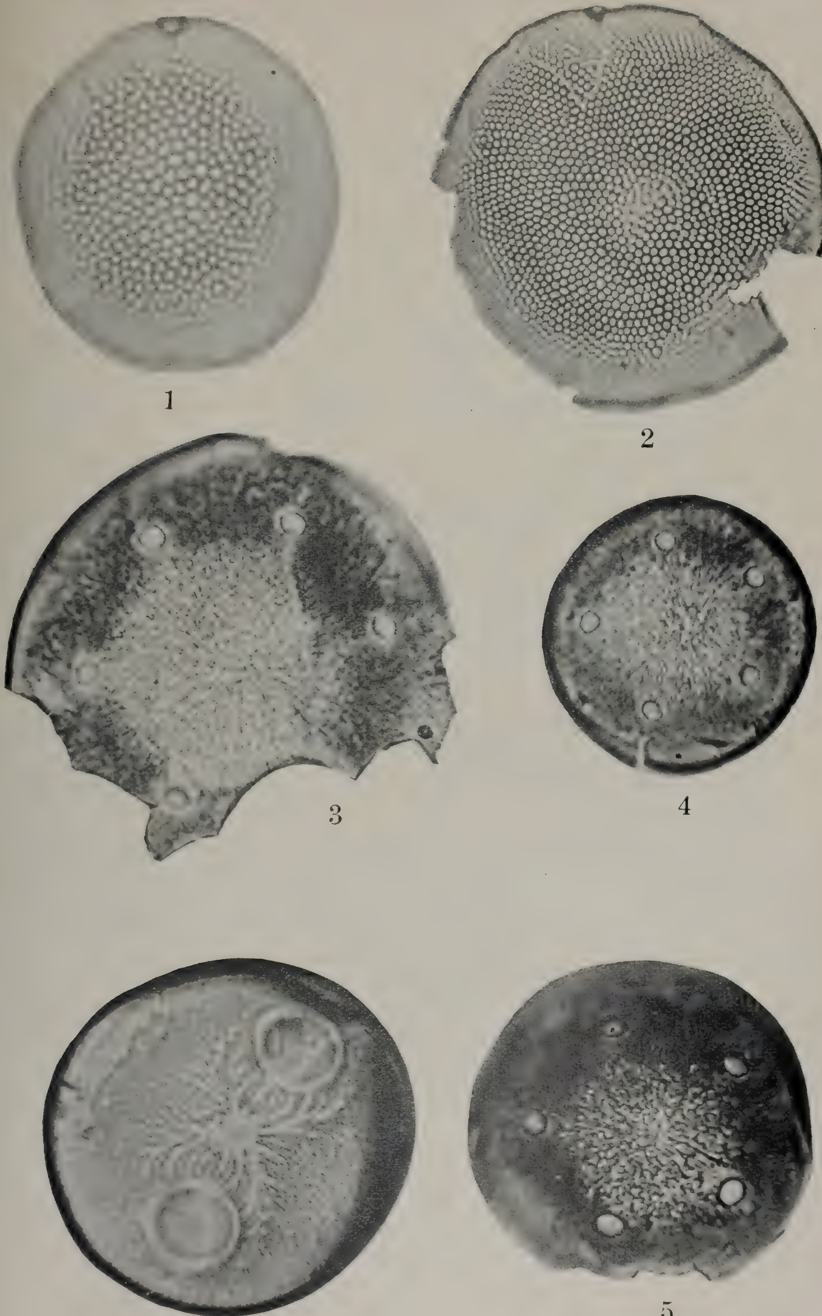
6. *Auliscus haucki Pantocsek.* Plesiotype (No. 3313, C.A.S.) from Loc 1832. Diameter, 0.0456 mm.

Loc. 1832, Calif. Acad. Sci., NE¼, Sec. 2, T. 1 N., R. 1 E., M.D.M.; 2½ miles south of Antioch, Contra Costa County, California. Kreyenhagen shale. C. C. Church, G. D. Hanna, O. P. Jenkins and J. A. Taff, Colls., January, 1930. The collection came from an abandoned quarry which appeared to be located well toward the base of the diatom-bearing shales.

Loc. 2256, Calif. Acad. Sci., W¼ corner, Sec. 1, T. 7 S., R. 7 E., M.D.M.; ½ mile southwest of Crow Hill, Stanislaus County, California. G. D. Hanna and F. A. Menken, Colls., September, 1930. Kreyenhagen shale; near top of exposed formation at this point.

Cal. State Div. of Mines

Hanna, Plate C.



DIATOMS OF THE KREYENHAGEN SHALE.

EXPLANATION OF PLATE D

Fig.

1. *Corbisema triacantha* (Ehrenberg). Plesiotype (No. 3269, C.A.S.) from Loc. 894. Extreme width, 0.050 mm.

2. *Corbisema apiculata* (Lemmermann). Plesiotype (No. 3270, C.A.S.) from Loc. 894. Extreme width, 0.0688 mm.

3. *Mesocena apiculata* Schulz. Plesiotype (No. 3271, C.A.S.) from Loc. 995. Length of one side, 0.050 mm.

4. *Dictyocha aperta* Hanna, n.sp. Holotype (No. 3272, C.A.S.) from Loc. 894. Extreme width, 0.0526 mm.

5. *Dictyocha (?) biapiculata* Lemmermann. Plesiotype (No. 3273, C.A.S.) from Loc. 894. Length 0.1420 mm.

6. *Dictyocha (?) biapiculata* Lemmermann. Plesiotype (No. 3274, C.A.S.) from Loc. 894. Length 0.0732 mm.

7. *Dictyocha hexacantha* Schultz. Plesiotype (No. 3275, C.A.S.) form Loc. 995. Diameter, 0.0289 mm.

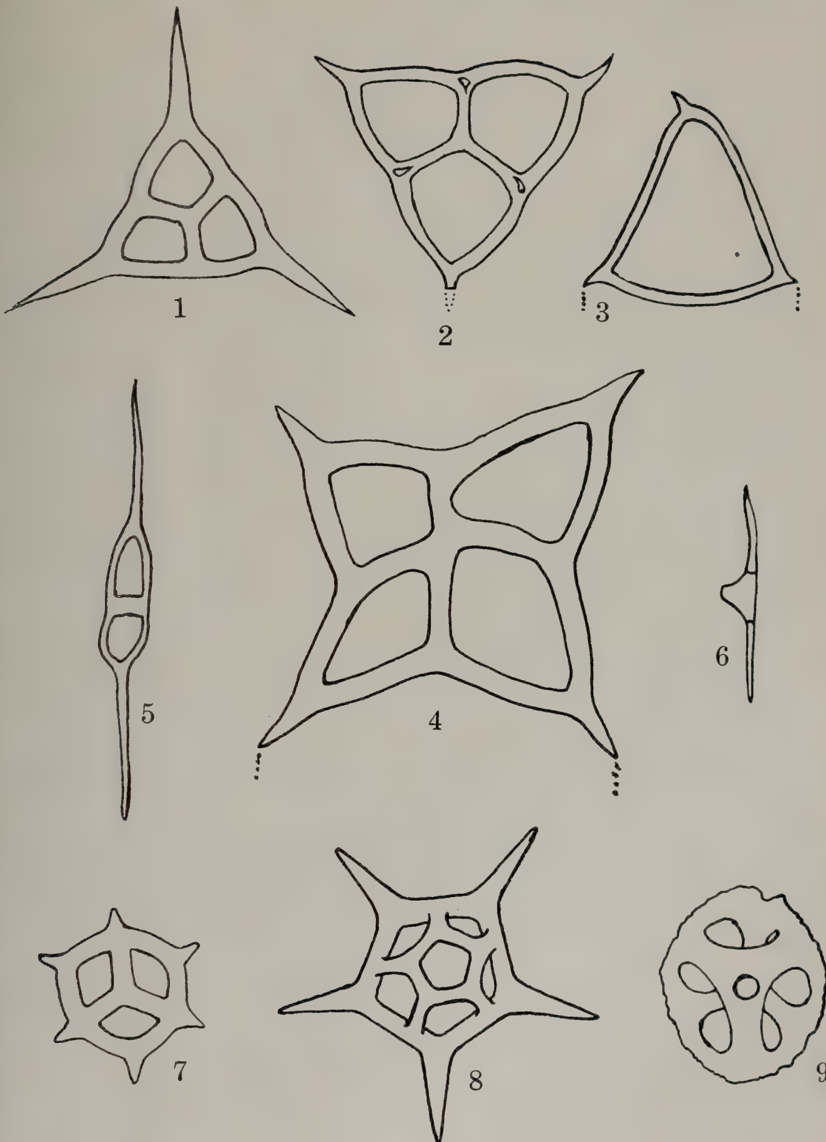
8. *Distephanus variabilis* Hanna, n.sp. Plesiotype (No. 3276, C.A.S.) from Loc. 894. Extreme diameter, 0.0688 mm.

9. *Ebria antiqua* Schulz. Plesiotype (No. 3277, C.A.S.) from Loc. 894. Major diameter, 0.030 mm.

Loc. 894, Calif. Acad. Sci., Sec. 20, T. 19 S., R. 15 E., M.D.M.; Phoenix Canyon, a small branch of Oil Canyon, abount seven miles north of Coalinga, Fresno County, California. Kreyenhagen shale. G. D. Hanna, Coll., January, 1924. The collection came from about 100 feet below the top of the formation near a prominent talus slope which reaches the creek bottom.

Loc. 995, Calif. Acad. Sci., Sec. 19, T. 18 S., R. 15 E., M.D.M.; Domengine Ranch, Fresno County, California. Kreyenhagen shale. The collection came from an exposure on the road to Ragged Valley, 1860 feet (surface distance) above the base of the siliceous shales. G. D. Hanna, Coll., December, 1926.

Cal. State Div. of Mines Hanna, Plate D.



SILICOFLAGELLATES OF THE KREYENHAGEN SHALE.

EXPLANATION OF PLATE E.

Fig.

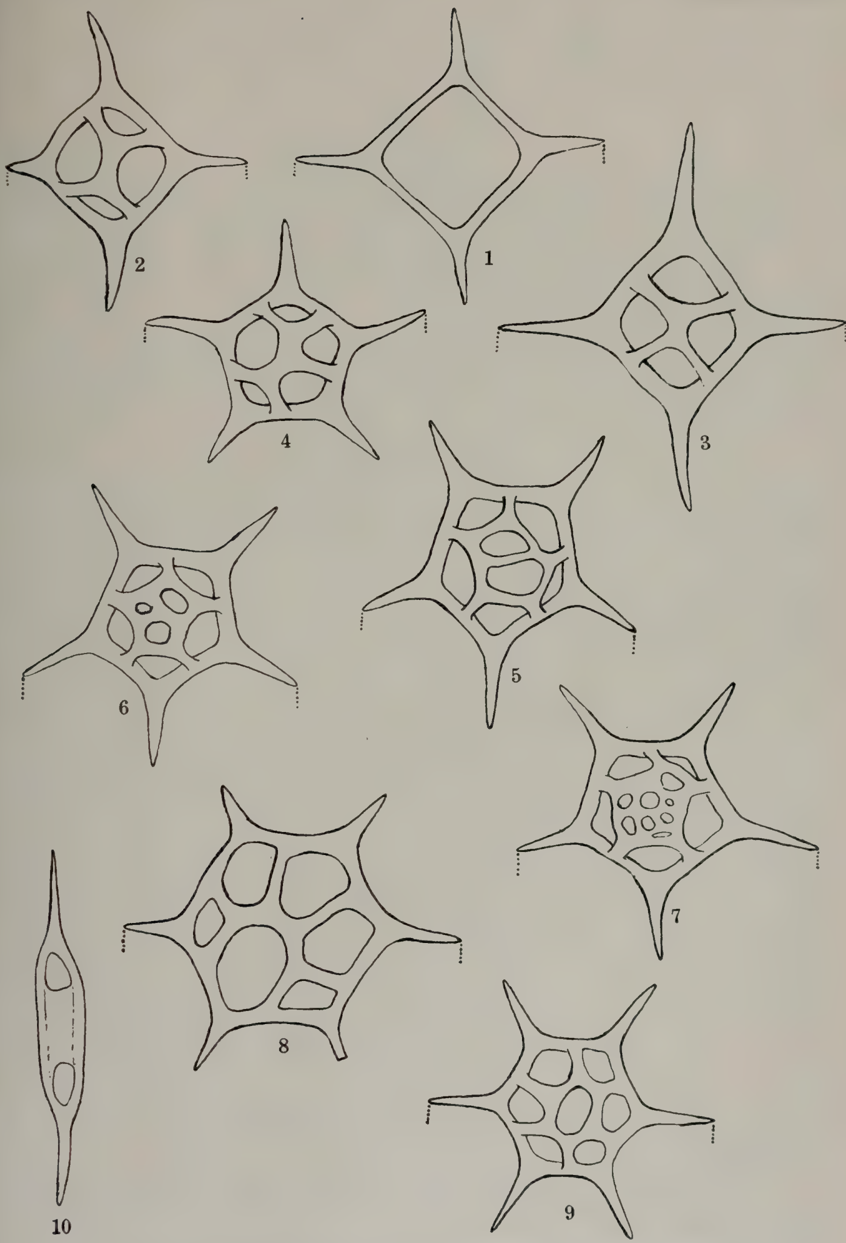
1. *Mesocena occidentalis* Hanna, n.n. Holotype (No. 3278 C.A.S.) from Loc. 1832; width, 0.0750 mm.
2. *Dictyocha longispina* Lemmermann. Plesiotype (No. 3279 C.A.S.) from Loc. 1832; width, 0.0566 mm.
3. *Dictyocha longispina* Lemmermann. Plesiotype (No. 3280 C.A.S.) from Loc. 1832; width, 0.0844 mm.
4. *Distephanus variabilis* Hanna, n.sp. Paratype (No. 3281 C.A.S.) from Loc 1832; width, 0.0666 mm.
5. *Distephanus variabilis* Hanna, n.sp. Paratype (No. 3282 C.A.S.) from Loc. 1832; width, 0.0656 mm.
6. *Distephanus variabilis* Hanna, n.sp. Paratype (No. 3283 C.A.S.) from Loc. 1832; width, 0.0696 mm.
7. *Distephanus variabilis* Hanna, n.sp. Holotype (No. 3284 C.A.S.) from Loc. 1832; width, 0.0772 mm.
8. *Distephanus irregularis* Hanna, n.sp. Paratype, (No. 3285, C.A.S.) from Loc. 1832; width, 0.080 mm.
9. *Distephanus irregularis* Hanna n.sp. Holotype (No. 3286, C.A.S.) from Loc. 1832; width, 0.0654 mm.
10. *Dictyocha* (?) *biapiculata* Lemmermann. Plesiotype (No. 3287 C.A.S.) from Loc. 1832; length, 0.1126 mm.

Loc. No. 1832, Calif. Acad. Sci., NE¼, Section 2, T. 1 N., R. 1 E., M.D.M.; 2½ miles south of Antioch, Contra Costa County, California. Kreyenhagen shale. C. C. Church, G. D. Hanna, Olaf P. Jenkins and J. A. Taff, Colls., January, 1930.

The collection came from an abandoned quarry which appeared to be located well toward the base of the diatom-bearing shales.

Cal. State Div. of Mines

Hanna, Plate E.



SILICOFLAGELLATES OF THE KREYENHAGEN SHALE.

FORAMINIFERA OF THE KREYENHAGEN SHALE

By C. C. Church*

INTRODUCTION

For many years the Kreyenhagen shale has been known to be rich in foraminifera. The earlier writers mentioned them largely to indicate the organic nature of the shale, but within the last few years, the study of foraminifera and other micro-organisms has proved that such forms have a direct and significant value in the recognition and correlation of geologic formations.

On the basis of samples collected from various outcrops of doubtful Kreyenhagen equivalence and from well cores yielding foraminifera, it has been possible to connect the various scattered outcrops and to discern the possible lateral extent of this important lithologic unit.

In the present paper, only the broader phases of the general problem are considered and such matters as complete faunal lists, synonomy, description, etc., are sacrificed that the purposes they serve may be more clearly set forth. Later, more detailed taxinomic information will be published elsewhere. For advice concerning new and questionable species, I am indebted to J. A. Cushman of Sharon, Massachusetts. I am also deeply indebted to G. D. Hanna and L. C. Decius of the Associated Oil Company, for valuable aid in the work and permission to publish, and to O. P. Jenkins, who submitted material and suggested the problem.

The first good foraminifera seen by the writer from an outcrop questionably referred to the Kreyenhagen were submitted by O. P. Jenkins. The shale came from the Markley formation in Contra Costa County, California, and had been described by B. L. Clark. He correlated it with the Kreyenhagen shale farther south, on lithologic and faunal grounds. At the type locality of the Markley in Markley Canyon, Contra Costa County, the light-gray diatomaceous-shale phase is only about 150 feet thick and the foraminifera are rather scarce but a few miles to the east in an old quarry, and in the creek bed at its base, a greater thickness of the shale is exposed and the micro-fossils are well preserved. This locality is just south of Antioch in the NE$\frac{1}{4}$, Sec. 2, T. 1 N., R. 1 E., M.D.M., Contra Costa County, California. At this locality, a fine assemblage of well-preserved foraminifera was found along with perfectly-preserved radiolaria, diatoms and silicoflagellates. The foraminifera were used in subsequent work for comparison and are sufficiently distinctive to make correlation with other outcrops facile and certain.

Shale carrying recognized Kreyenhagen foraminiferal faunas has been found in the following localities in the San Joaquin Valley, south of the Markley occurrence.

* Paleontologist, Associated Oil Company, San Francisco.

BYRON, CONTRA COSTA COUNTY

At one and one-half miles west of the town of Byron a felt-like diatomite was secured in which foraminifera were preserved. It was taken from a pit. A similar shale was found one-half mile northwest of Byron Hot Springs where it had been brought to the surface by burrowing animals. The fauna here is like that from farther north.

ORTIGALITA CREEK AREA

Just south of the mouth of Ortigalita Creek in the first low hills the Kreyenhagen is well exposed. It consists of something over seven hundred feet of relatively unaltered, white diatomaceous shale carrying abundant diatoms and radiolaria and a few foraminifera. The latter are usually small but are recognizable as of the Kreyenhagen.

At the Panoche Creek and Tumey Gulch localities (map, Anderson and Pack, U.S.G.S. Bull. 603) only moulds of foraminifera were found in the shales, but the locality one mile southeast of Tumey Gulch, from which D. D. Condit obtained a fauna from his "D" horizon, was not visited.

ARROYO CIERVO LOCALITY

In the first deep arroyo north of Arroyo Ciervo in Sec. 25, T. 16 S., R. 13 E., M.D.M., poorly preserved foraminifera were found at the top of the Kreyenhagen and just below the unconformity at the base of the "Leda zone" or zones "A" and the upper part of zone "B" of Mr. Condit. This fauna is probably considerably higher in the section than that from Contra Costa County and was found to correspond to that found farther south in Cantua Creek about fifty feet below the top of the formation; it is listed by Mr. Condit as being from his "D" horizon.

SALT CREEK, FRESNO COUNTY

Foraminifera were not found preserved in the upper few hundred feet of the section on Salt Creek, Fresno County, but moulds and impressions were common. In the lower part, however, in the SW$\frac{1}{4}$, Sec. 10, T. 18 S., R. 14 E., M.D.M., about 150 feet above the base a good fauna was found. The presence of many of the more characteristic species found in Contra Costa County is sufficient proof of the age equivalence of the two formations, although specific differences indicate slightly different horizons. This lower fauna in Salt Creek is also related to the fauna found at the top of the section in Cantua Creek, as certain species, notably *Eponides* cf. *pygmea* Hantken, are common to both.

OIL CANYON, NORTH OF COALINGA

Foraminifera were found in shale collected from a cut in the road which leads up Oil Canyon, north of Coalinga. The Kreyenhagen is well exposed in the upper part of the formation, but being near the axis of the Coalinga anticline, it is highly distorted. The foraminifera-bearing shale is judged to be toward the base and while the preservation

is only fair, the fauna is the same as that from the quarry in Contra Costa County. On the southwest slope of the high hill at the head of the main east branch of Oil Canyon, northeast of Oil City, the basal chocolate-brown shales of the Kreyenhagen rest on the gray sandy-clay shale of the Domengine Eocene without any noticeable unconformity but the two formations are separated by a two-foot bed of gypsiferous clay and glauconitic sand. Eight feet above the contact, a gray clay-shale about twenty feet thick intervenes. Foraminifera are present in this shale, but are more closely related to the Eocene reef beds in Coalmine Canyon than to the Kreyenhagen. At the top of this shale, a thin nodular seam of limestone is topped by an eight-inch lateritic zone having a black carbonaceous seam at the top; this, in turn, is separated from the brown shale above by a white chalky layer. These beds suggest a brief return to shallower water conditions. The brown shales above and below the gray contain abundant replaced radiolaria but no foraminifera were found.

COALMINE CREEK, NORTHWEST OF COALINGA

In two branches of Coalmine Creek, located northwest of Coalinga, about four hundred feet of Kreyenhagen shale are exposed. The upper two-thirds are thinly-bedded, brown to grayish, platy and siliceous with a few yellowish, limy ribs; some of the more argillaceous beds carry foraminifera. The lower third is distinctly gray and grades downward from platy to massive clay-shale into brown shale overlying the Eocene reef beds. These lower strata contain abundant foraminifera and radiolaria. Diatoms are also found preserved locally in the gray platy portion of this lower part. These lower shales appear to be conformable and intergradational with the Eocene reef-forming beds and probably represent a more extensive development of the gray clay-shale found near the base of the Kreyenhagen shale in Oil Canyon. This is borne out by the fauna.

CANOAS CREEK

The brown siliceous shale of the Canoas Creek locality did not yield preserved foraminifera but the silty clay shale below it was found to contain them. This fauna has certain forms which show its intimate relation with the basal Kreyenhagen and upper Eocene of Coalmine Canyon, and is, without much doubt, the southward extension of the lower clay-shale phase. The foraminifera have been listed and the stratigraphy well described in a recent article by F. E. von Estorff. There is little doubt in the mind of the present author that these foraminifera represent some part of the Upper Eocene.

DEVILS DEN—WAGONWHEEL MOUNTAIN AREA

The area west of Wagonwheel Mountain, in the region of Devils Den, represents the southernmost definitely known outcrops of Kreyenhagen shale. On the west slope of the low hills west of Wagonwheel Mountain, the uppermost part of the Kreyenhagen is represented by seventy-five to one hundred feet of chocolate-brown to gray shale with two or

three hard yellowish limy beds at intervals of twenty feet. The shale contains numerous foraminifera and samples were taken thirty and fifty feet, respectively, below the top. They are, without much doubt, Kreyenhagen. Below this shale sandstone predominates.*

NAPA JUNCTION AND VACAVILLE

Other localities outside of the San Joaquin Valley where the Kreyenhagen may be represented are between Napa Junction and Vacaville. Material collected from one mile east of Napa Junction in a road cut was submitted by James Kirby and similar samples collected by G. D. Hanna were also examined; their Kreyenhagen equivalence is highly probable. The thickness in this northern locality is not yet known because of complicated structural conditions.

SANTA CRUZ MOUNTAINS

In the lower part of the San Lorenzo series, 5.8 miles north of Boulder Creek on the highway, samples were collected by L. G. Hertlein and Olaf P. Jenkins. From the brownish silty-shale collected by them, the writer secured a rather poorly-preserved fauna of foraminifera, which appears to be equivalent to that from Contra Costa County.

SAN JOAQUIN VALLEY

In wells drilled for oil in the San Joaquin Valley, the Kreyenhagen shale has been encountered a number of times. In 1925, the Associated Oil Company drilled a well in Sec. 35, T. 13 S., R. 16 E., M.D.M., in about the center of the valley. Diatomaceous shale with foraminifera was cored from 4772 to 4973 feet and in a paper by J. A. Taff and G. D. Hanna published in 1927, was correlated with the Kreyenhagen shale north of Coalinga. Foraminifera secured from this shale were subsequently examined by the writer and found to be equivalent to those from the Markley (Kreyenhagen) of Contra Costa County and the equivalent shale in Oil Canyon. The shale body in this well was 201 feet thick and gave evidence of being unconformable on the Eocene below. The same company drilled another well, an offset to the first, in Sec. 36, about one-half mile northeast. Kreyenhagen shale, similar in every way to that in the first well, was cored from 4790 to 5024 feet or a thickness of 239 feet. No gradational beds were seen at the Eocene contact. This meager thickness of the shale in the center of the valley serves to indicate the extent of the thinning of the formation eastward from the outcrop. This thinning may be as much the result of denudation as a lessening of sedimentation.

The Western Gulf Oil Company, Lillis Welch No. 1 well, drilled in Sec. 22, T. 15 S., R. 12 E., M.D.M., was completed in 1930; it started practically on the outcrop of the Kreyenhagen shale and penetrated its entire thickness. Probably 1500 feet (vertical thickness) of the shale

* Below this sandstone (containing fossils similar to those of the basal part of the San Emigdio formation) are 850 feet of Kreyenhagen shale similar to that of the type locality on Reef Ridge and containing *Pecten interradiatus.* Note by Olaf P. Jenkins)

was drilled through. Diagnostic fossils were found abundantly in the cores.

AGE OF THE KREYENHAGEN SHALE

In considering the age of the Kreyenhagen, it has been pointed out in this and other papers, that a definite unconformity has not been found between the highest known Eocene and the base of the formation. The Kreyenhagen apparently owes its lithologic difference to the rather abrupt change from the fairly shallow-water Eocene to deep-water conditions. This is suggested by the large number of pelagic organisms present in the Kreyenhagen shale and its lack of coarse sediment. This type of change further removes the possibility of unconformity. It has also been pointed out that where the shallow-water conditions of the Eocene prevailed in Kreyenhagen time the fauna is likewise of Eocene appearance. In an examination of the more characteristic foraminifera, it is found that the form *Hastigerinella eocanica* Nuttall, which is common in the middle and lower part of the Kreyenhagen, is considered a typical upper Eocene form. The large *Planularia markleyana* n.sp. is very close to *P. kubinyii* Hantken. *Eponides* cf., *pygmea* Hantken, one of the common Kreyenhagen species is very close to the form described under that name by Hantken from the *Clavulina szaboi* fauna, which, according to Cushman, is probably basal Oligocene or upper Eocene. Other species are suggestive of the Eocene of Trinidad and Mexico. The odd new form *Plectofrondicularia jenkinsi* n.sp. has probably not been found before because of a possible limited range. It is quite probable that the absence of many of the more characteristic species of the lower and middle Kreyenhagen in other deposits in America, is due to some specialized condition of their environment. It is evident that while these forms were being deposited, uniform, fairly-deep-water conditions prevailed for a considerable period of time. It is also evident that while the great thickness of fine sediment was accumulating in the area north of Coalinga, more clastic sediments were being deposited to the south in the Devils Den area and no doubt elsewhere along the old shore line. It is quite probable (and there is some supporting evidence in favor of it) that a part of the Kreyenhagen is represented in the Santa Inez Mountains of Santa Barbara County. It may, in time, be recognized elsewhere in all its phases. Of the different phases of the Kreyenhagen fauna, it may be said in general, that the upper part is characterized by the fauna listed by D. D. Condit from his "D" zone; and the middle and lower part by the fauna figured in this present paper. Of the lowermost clay-shale fauna as developed from Coalinga southward, little more can be added at this time, as it requires more study. On the whole the fauna from the middle and lower Kreyenhagen appears to be upper Eocene.

Foraminifera in the Kreyenhagen contribute their share to the organic content of the shale but if we are to judge from the actual number of visable remains alone, they are probably not the most important from the standpoint of oil-generating organisms. It is not difficult to understand, however, how their importance may be inferred if a selected piece of the shale be examined under a hand lens; they may be so abundant as to give the shale a sandy appearance, or where

leached out, render the shale decidedly porous. It is probably safe to say that of the many classes of organisms contributing to the whole organic content, the foraminifera are one of the most important.

The specimens illustrated in the following plates have been deposited in the California Academy of Sciences.

EXPLANATION OF PLATE A

Fig.

1. *Eponides* cf. *pygmea* Hantken. Ventral view, Plesiotype (No. 5498 C.A.S) from Loc. 2370, Kirker Creek, Contra Costa County, California; one mile north of the old town of Nortonville. Length, 0.3 mm.; width, 0.28 mm.

2. *Eponides* cf. *pygmea* Hantken. Dorsal view, same specimen as fig. 1.

3. *Eponides* cf. *pygmea* Hantken. Peripheral view, same specimen as fig. 1.

4. *Plectofrondicularia jenkinsi* Church, n.sp. Apertural view. Paratype (No. 5499 C.A.S.) from Loc. 1832.

5. *Plectofrondicularia jenkinsi* Church, n.sp. Side view. Paratype (No. 5499 C.A.S.) from Loc. 1832, Length, 1.25 mm.; width, 0.2 mm.

6. *Planularia markleyana* Church, n.sp. Side view. Holotype (No. 5500 C.A.S.) from Loc. 1832. Length, 1.2 mm.; width, 0.85 mm. Megalospheric form.

7. *Plectofrondicularia jenkinsi* Church, n.sp. Side view. Paratype (No. 5501 C.A.S.) from Loc. 1832. Length, 0.73 mm.; with, 0.16 mm.

8. *Plectofrondicularia jenkinsi* Church, n.sp. Apertural view, same specimen as fig. 7.

9. *Plectofrondicularia jenkinsi* Church, n.sp. Front view. Holotype (No. 5502 C.A.S.) from Loc. 1832. Length, 1.3 mm.; width, 0.18 mm. Named for Dr. Olaf P. Jenkins.

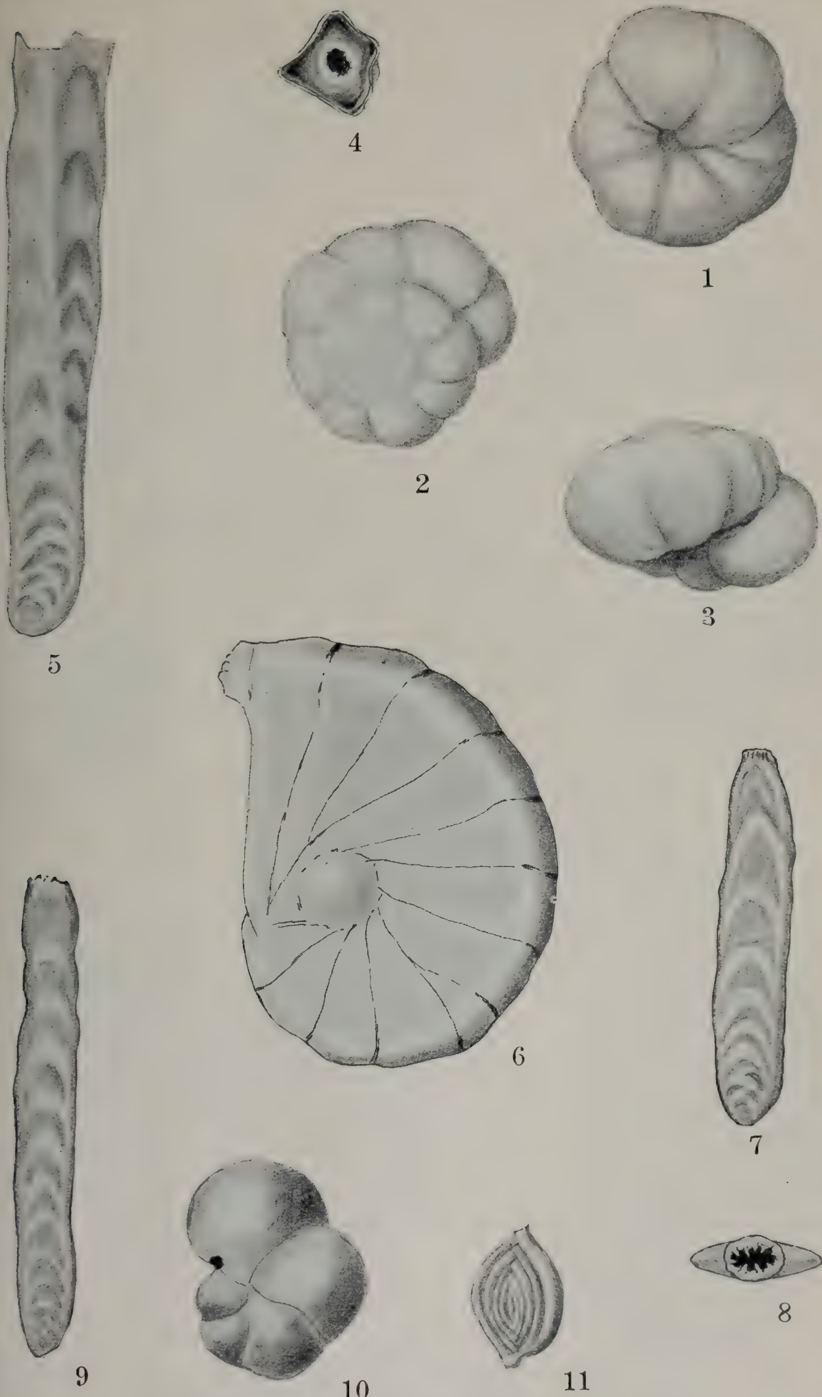
10. *Pullenia lillisi* Church n.sp. Side view. Holotype (No. 5503 C.A.S.) from Loc. 1832. Length, 0.3 mm.; width, 0.22 mm.

11. *Spiroloculina* sp. (?) Side view. Plesiotype (No. 5504 C.A.S.) from Loc. 1832. Length, 0.42 mm.; width, 0.28 mm.

Loc. 1832, Calif. Acad. Sci., NE¼ Sec. 2, T. 1 N., R. 1 E., M.D.M., 2½ miles south of Antioch, Contra Costa County, California; C. C. Church. G. D. Hanna, O. P. Jenkins and J. A. Taff, colls., January, 1930. The collection came from an abandoned quarry which appeared to be toward the base of the diatom-bearing shales.

Cal. State Div. of Mines

Church, Plate A



FORAMINIFERA OF THE KREYENHAGEN SHALE.

Drawn by the author.

EXPLANATION OF PLATE B.

Fig.

1. *Planularia markleyana* Church, n.sp. Side view (broken). Paratype (No. 5505 C.A.S.) locality, Western Gulf Oil Co., Lillis Welch No. 1 well, Sec. 22, T. 15 S., R. 12 E., M.D.M., Fresno County, California; depth 1852 feet. Keeled form.

2. *Bulimina* sp. (?) Side view. Plesiotype (No. 5506 C.A.S.) from Loc. 1832. Length, 0.32 mm.; width, 0.16 mm.

3. *Bulimina* sp. (?) Apertural view, same specimen as in fig. 2.

4. *Bulimina* cf. *semicostata* Nuttall. Side view. Plesiotype (No. 5507 C.A.S.) from Loc. 1832. Length, 0.3 mm.; width, 0.12 mm.

5. *Bulimina* cf. *semicostata* Nuttall. Apertural view. Plesiotype (No. 5508 C.A.S.) from Loc. 1832. Length, 0.25 mm.; width 0.16 mm.

6. *Bulimina* cf. *semicostata* Nuttall. Side view. Plesiotype (No. 5508 C.A.S.), same specimen as fig. 5.

7. *Robulus* sp. (?) Side view. Plesiotype (No. 5509 C.A.S.) from Loc. 1832. Length, 0.84 mm.; width, 0.72 mm.

8. *Hastigerinella eocanica* Nuttal. Side view. Plesiotype (No. 5510 C.A.S.) from Salt Creek, Fresno County, California. SW¼, Sec. 10, T. 18 S., R. 14 E., M.D.M. Length, 0.6 mm.; width, 0.4 mm.

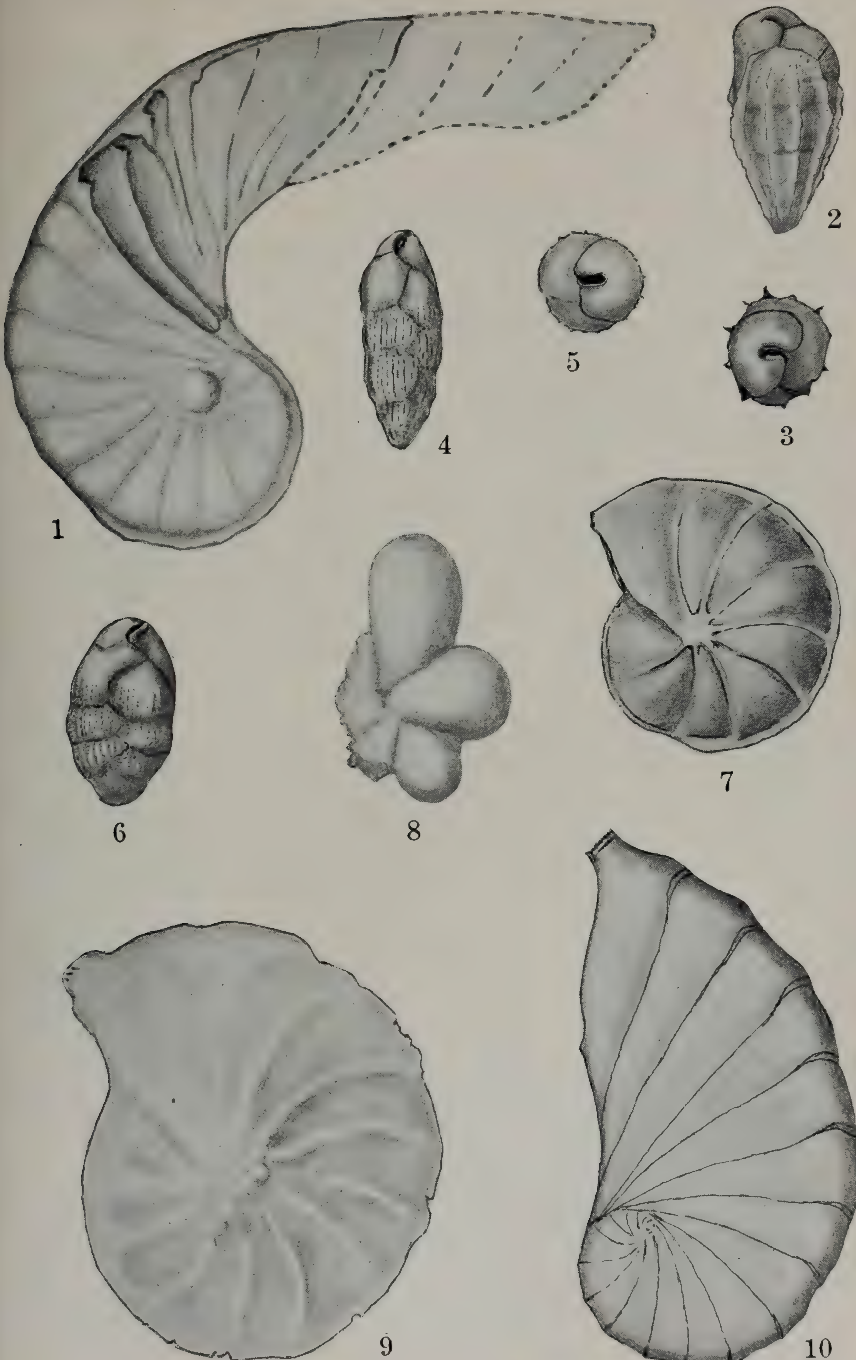
9. *Robulus* sp. (?) Side view. Plesiotype (No. 5511 C.A.S.) from Loc. 1832. Length, 1.2 mm.; width, 1.0 mm. Probably same species as fig. 7.

10. *Planularia markleyana* Church, n.sp. Side view. Paratype (No. 5512 C.A.S) from Loc. 1832. Length, 1.5 mm.; width, 0.72 mm.

Loc. 1832, Calif. Acad. Sci., NE¼, Sec. 2, T. 1 N., R. 1 E., M.D.M., 2½ miles south of Antioch, Contra Costa County, California; C. C. Church, G. D. Hanna, O. P. Jenkins and J. A. Taff, Colls., January, 1930. The collection came from an abandoned quarry which appeared toward the base of the diatom-bearing shales.

Cal. State Div. of Mines

Church, Plate B.



FORAMINIFERA OF THE KREYENHAGEN SHALE.

Drawn by the author.

EXPLANATION OF PLATE C.

Fig.

1. *Gyroidina soldanii* d'Orbigny. Dorsal view. Plesiotype (No. 5513 C.A.S.) Loc. 1832. Length, 0.24 mm.; width, 0.18 mm. Not typical *G. soldanii* d'Orbigny.

2. *Gyroidina soldanii* d'Orbigny. Peripheral view. Plesiotype (No. 5514 C.A.S.) Loc. 1832. Length, 0.24 mm.; width, 0.18 mm.

3. *Gyroidina soldanii* d'Orbigny. Ventral view. Plesiotype (No. 5514 C.A.S.), same specimen as fig. 2.

4. *Cassidulina globosa* Hantken. Dorsal view. Plesiotoype (No. 5515 C.A.S) Loc. 1832. Length, 0.18 mm.; width, 0.16 mm.

5. *Cassidulina globosa* Hantken. Apertural view. Plesiotype (No. 5516 C.A.S.) Loc. 1832. Length, 0.18 mm.; width, 0.14 mm.

6. *Nodogenerina bradyi* Cushman. Side view. Plesiotype (No. 5517 C.A.S.) from Loc. 1832. Length, 0.62 mm.; width, 0.14 mm.

7. *Nodogenerina bradyi* Cushman. Side view. Plesiotype (No. 5518 C.A.S.) from Loc. 1832. Length, 0.72 mm.; width, 0.12 mm.

8. *Lenticulina* cf. *crepidula* Fichtel & Moll. Plesiotype (No. 5519 C.A.S.) from Loc. 1832. Length, 0.61 mm.; width, 0.28 mm.

9. *Lenticulina* cf. *crepidula* Fichtel & Moll. Apertural view. Plesiotype (No. 5519 C.A.S.), same specimen as fig. 8.

10. *Lenticulina* cf. *crepidula* Fichtel & Moll. Apertural view. Plesiotype (No. 5520 C.A.S.) from Loc. 1832. Length, 0.73 mm.; width, 0.36 mm.

11. *Lenticulina* cf. *crepidula* Fichtel & Moll. Side view. Plesiotype (No. 5520 C.A.S.), same specimen as fig. 10.

12. *Eponides* cf. *pygmea* Hantken. Apertural view. Plesiotype (No. 5521 C.A.S.) from Salt Creek, Fresno County, California, SW¼, Sec. 10, T. 18 S., R. 14 E., M.D.M. X 90.

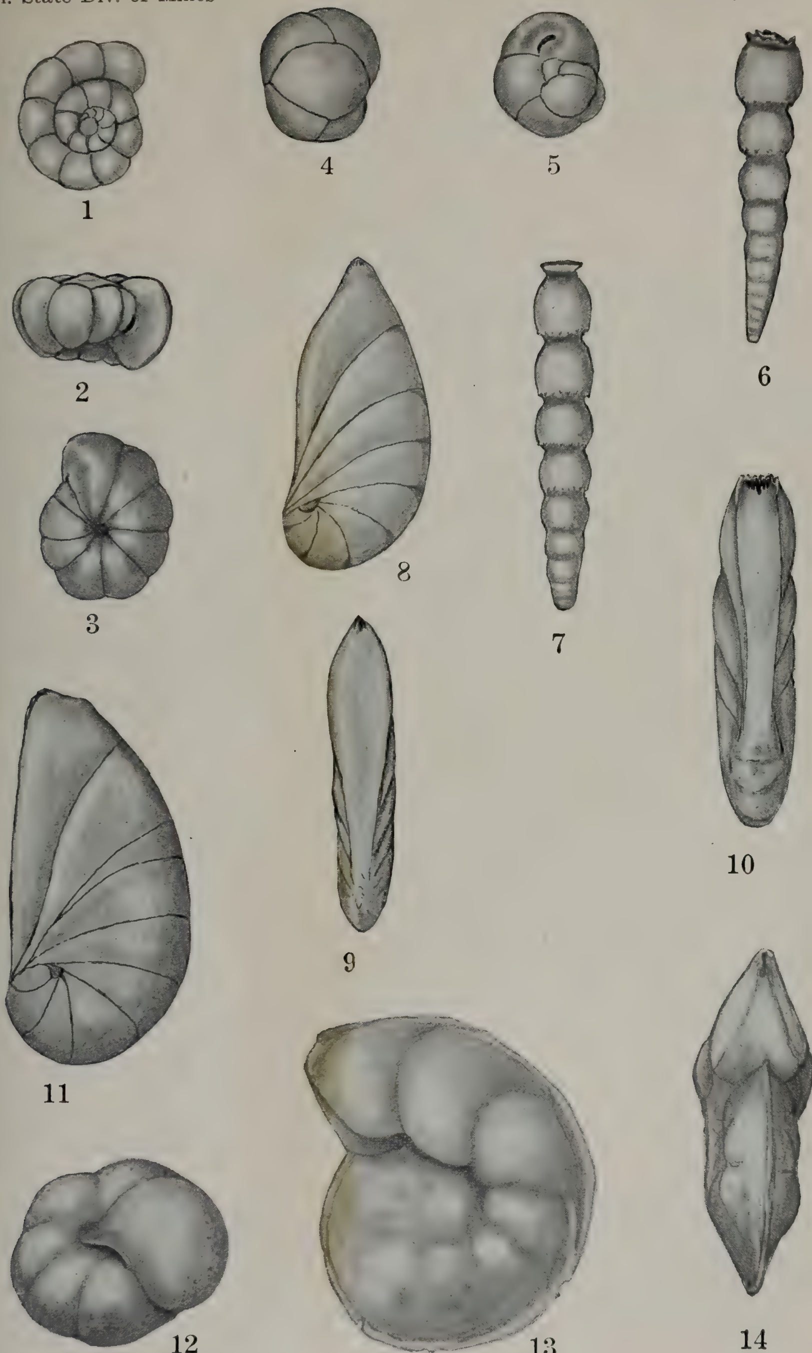
13. *Robulus welchi* Church, n.sp. Side view. Holotype (No. 5522 C.A.S.) from Salt Creek, Fresno County, California, SW¼, Sec. 10, T. 18 S., R. 14 E., M.D.M. Length, 0.5 mm.; width, 0.3 mm.

14 *Robulus welchi* Church, n.sp. Apertural view. Holotype (No. 5522) same specimen as fig. 13.

Loc. 1832, Calif. Acad. Sci., NE¼, Sec. 2, T. 1 N., R. 1 E., M.D.M., 2½ miles south of Antioch, Contra Costa County, California; C. C. Church, G. D. Hanna, O. P. Jenkins and J. A. Taff, Colls. January, 1930. The collection came from an abandoned quarry which appeared to be toward the base of the diatom-bearing shale.

Cal. State Div. of Mines

Church, Plate C.



FORAMINIFERA OF THE KREYENHAGEN SHALE.

Drawn by the author.

PRELIMINARY REPORT OF THE GEOLOGY OF SANTA CRUZ ISLAND, SANTA BARBARA COUNTY, CALIFORNIA[1]

By William W. Rand

INTRODUCTION

This paper presents briefly some of the results of a five-months' geological examination of Santa Cruz Island, carried on during the summers of 1928, 1929, and 1930. It is a short preliminary statement which the writer expects to amplify later.

Location.

The Santa Barbara or Channel Islands comprise a group of four islands, flanking the coast of southern California between the longitudes of Ventura and Point Conception, and separated from the coast by the Santa Barbara Channel, the width of which is about twelve miles on the east, and about twenty-seven miles on the west. All of the islands are included in a rectangle bounded by 33° 50′ and 34° 05′ north latitude, and by 119° 20′ and 120° 30′ west longitude.

Santa Cruz is the largest, longest, and highest of the four islands. Its area is 91.16 square miles, extreme length 2[illegible].47 miles, breadth, from 1.78 to 6.78 miles, and maximum elevation 2,407 ft. Prisoners' Harbor, on the north side, is just twenty-seven miles due south of the Santa Barbara wharf.

Other Investigations of the Region.

In 1889, W. A. Goodyear, then Field Assistant to the State Mineralogist, spent about three weeks on Santa Cruz Island, and published his observations in the Ninth Annual Report of the State Mineralogist.[2]

In 1929, more than a year after the writer began his field study, an economic investigation of part of the island was undertaken, but until the present time, Goodyear's report is the only published account of the geology of the entire area.

GENERAL GEOLOGY

The formations exposed on the Island range in age from pre-Cretaceous to Recent, but do not furnish a complete record of that time interval.

The oldest rocks are foliated chlorite-bearing schists, which were intruded by quartz-diorite of two ages. This complex was deeply eroded, and unconformably overlain by Eocene and Miocene sediments. Large quantities of volcanic breccias and agglomerates, with a lesser

[1] Published by permission of the Department of Geology, University of California, and through the courtesy of the Santa Cruz Island Company and National Trading Company.

[2] Goodyear, W. A., Santa Cruz Island: Ninth Annual Report of the State Mineralogist, for the year ending December 1, 1889 (1890).

amount of flows, were extruded in Middle Miocene time, and were followed abruptly by marine siliceous shales typical of the upper part of the Monterey Group. The shales and underlying rocks were folded, eroded, and then overlain in places by thin almost flat-lying Pliocene beds, of which only a few small patches remain. Later, marine terraces were cut at several levels, and show that after Pliocene time the Island was elevated to different heights; but drowned valley-mouths show that the latest movement was slightly downward.

STRATIGRAPHY

Pre-Cretaceous Rocks.

Chlorite schist.

The oldest rock on the Island is dull olive-green schist which weathers brick-red. It is composed of abundant chlorite with quartz and feldspar, a considerable amount of epidote and titanite, and some magnetite and pyrite. The planes of schistosity are clear, but it is not certain whether they follow original bedding planes. The schist is rather basic which suggests that the original rock was a basic tuff, and in some samples textures suggestive of basaltic or andesitic rocks remain. The mineral assemblage and typical crystalloblastic texture indicate metamorphism in the epi-zone. No statement can yet be made concerning the age of these rocks except that they are older than the quartz-diorite intrusions. The writer saw no soda amphiboles in this schist and there appears to be no reason to consider it a member of the Franciscan formation.

Older quartz-diorite.

The first rock which intruded the old schist is light greenish-gray, coarse-grained, massive, highly quartzose quartz-diorite, sericitized and epidotized. Dynamic metamorphism has altered this rock to gneiss where thin apophyses of it cut the schist.

Younger quartz-diorite.

The second rock to intrude the schist consists mainly of quartz-hornblende diorite whose composition and texture are variable from place to place. In contrast to the earlier intrusion, it is fresh; the hornblende is not chloritized and the feldspar shows very little sericitization. The minerals are not strained except locally near the contact with the schist and earlier quartz-diorite. It contains a notably higher proportion of hornblende, and lower proportion of quartz than the rocks of the first intrusion. It has been cut by acid dikes and later by basic dikes.

Eocene.

Martinez formation.

The oldest sedimentary rocks exposed are of Lower Eocene (Martinez) age. These consist of rusty-tan colored conglomerate, sandstone and sandy siltstone, exposed over only a small area; the thickness is indeterminate because the base is not exposed. The following fossils were found in them:

Cucullaea (Cyphoxis) mathewsoni Gabb.
Glycimeris major Stanton.

Callocardia simiensis Nelson.
Turritella (Haustator) pachecoensis Stanton.
Turritella infragranulata Gabb.

Domengine formation.

The Domengine formation, which overlies the Martinez, is divided into a lower siltstone, a middle sandstone and conglomerate, and an upper siltstone. The siltstones are very much alike and could not be mapped separately if the intervening sandstone and conglomerate were absent. The siltstones are light gray when fresh, but weather to light tawny yellow. They are rather poorly indurated except for thin intercalations of calcareous sandy silt, and are thinly and evenly bedded. Foraminifera are abundant in certain layers, and megascopic fossils are well preserved in the harder sandy beds.

The middle member is composed of well indurated sandstone and massively bedded conglomerate made up of well rounded boulders averaging three to four inches in diameter. Porphyritic rhyolite, andesite, various plutonic rocks, quartzite, and limestone are all represented, but no Franciscan rock types occur. Irregular lenses and thick beds of gray coarse-grained arkose (weathering rusty tan) occur in this member and are notable for the abundance of biotite. The proportion of conglomerate to sandstone decreases rapidly to the south and east; in the most easterly exposures conglomerate is almost absent.

Fossils were found throughout the formation, and include the following forms:

Globularia hannibali Dickerson.
Cylichnina tantilla Anderson & Hanna.
Venericardia hornii Gabb var.
Corbula cf. parilis Gabb.
Ostrea cf. idriaensis Gabb.
Turritella applini M. Hanna.
Turritella variata Conrad.
Amaurellina (Euspirocromium) clarki Stewart.

Miocene (Monterey Group).

Vaqueros formation.

Unconformably overlying the Domengine is the Vaqueros formation, which consists of fairly well-bedded conglomerates, with intercalated beds of coarse sandstone. The boulders of the conglomerates are mainly of plutonic rocks, together with porphyritic volcanics probably derived from the Eocene conglomerate below. Franciscan fragments are extremely rare in the Vaqueros. The following fossils, collected from the sandstone, form the basis for the age determination:

Pecten estrellanus Conrad.
Pecten miguelensis Arnold.
Pecten vanvlecki Arnold.
Cardium vaquerosensis Arnold.
Phacoides cf. nuttalli Conrad.

On the north flank of the Christy anticline the Vaqueros beds are much thinner than on the south flank, as will be seen from the map and section. A pronounced unconformity separates the Vaqueros from the

Eocene, and boulders of fossiliferous Eocene sandstone occur in the basal beds of the Vaqueros.

Temblor formation.

San Onofre Breccia.

The San Onofre breccia, bluish-gray, bedded sandstone, conglomerate and breccia, composed in greatest part of flakes and blocks of various types of schists, makes up the lower part of the Temblor formation, which overlies the Vaqueros.

Soda amphiboles such as are characteristic of the Franciscan rocks are more or less abundant in all of the schists, and the rocks correspond in essential characters to the San Onofre schist-breccia with gray sandy matrix, described by Woodford.[3] Breccia with earthy matrix was not found. The maximum diameter of the blocks is about five feet, considerably less than that of the blocks at the type locality. Cross-bedding is distinct at several places, and indicates a source to the west. Because no typical Franciscan bedrock occurs on the island, it is not possible to fix the position of the source rock, but it was very probably somewhere west of the present Island.

At the base of this breccia there is a siltstone member about 150 feet thick, which contains typical Temblor fossils, just as do the sandstones above the breccia; thus the Temblor age of the breccia is well established.

Upper Sandstone and Conglomerate.

Well-bedded, fossiliferous sandstones and conglomerate, which weather to tan, rest on the San Onofre breccia, in places with erosional unconformity. The sandstones, locally present at the base, grade upward and laterally into thick-bedded conglomerate composed mainly of acid, porphyritic volcanic rocks. There is very little admixture of the Franciscan rock types so abundant in the San Onofre below. The sandstone carries fossils of Temblor age.

Blanca tuff.

An extensive mass of distinctly bedded, water-deposited, acid to intermediate crystal-vitric tuffs, and conglomerates make up the Blanca tuff. Near the top there is a thin flow of andesite, preserved now in only two small remnants, on the tops of ridges. This flow is probably the forerunner of the thick series of volcanics to the north. The rocks of this unit dip southerly and form conspicuous, nearly white outcrops. Cross-bedding in the tuffs and conglomerates shows derivation from the north.

Volcanics.

Andesite and basalt breccias, agglomerates, and flows are thickly and irregularly bedded; with a few intercalations, usually less than 100 feet thick, of thin-bedded muddy tuffs. The latest flow exposed is of dacite, and is mapped separately. In petrologic character, type of deposition, and probably also in their age, these rocks correspond closely to those in the western Santa Monica Mountains.

[3] Woodford, A. O., The San Onofre Breccia, Its Nature and Origin: Univ. Calif. Pub., Bull. Dept. Geol. Sci., Vol. 15, No. 7, pp. 159–280, 1925.

From the map it can be seen that the volcanics are confined almost entirely to the north side of the Santa Cruz Island fault. West of the Isthmus, they dip northerly, while to the east of it, they have been folded to form an anticline whose axis trends northwest.

Siliceous shale.

The siliceous shale rests directly upon the volcanic rocks, with a sharp contact. This member includes yellowish gray, thinly laminated, siliceous and tuffaceous, foraminiferal and diatomaceous shale; dark gray bituminous shale; chert; and thin beds of sparsely fossiliferous limestone. A few thin beds of sandstone and of acid vitric tuff are present. A fauna from the base of this unit includes:

Mollusca

Arca obispoana Conrad.
Venericardia montereyana Arnold.
Pecten peckhami Gabb.

Foraminifera

Valvulineria californica Cushman.
Siphogenerina cf. collomi.
Nonionia sp.

Upper Pliocene.

Santa Barbara beds.

The Santa Barbara beds overlie the siliceous shales of the Monterey group with erosional and slight angular unconformity. They are gray, fairly well-bedded, highly fossiliferous shell-sandstones, composed mainly of finely broken shell fragments, weakly cemented with calcite. The beds contain many shells that are rounded as though by attrition on a beach. A number of fossils characteristic of the Santa Barbara beds on the mainland were collected.

Pleistocene.

Marine terrace deposits.

Pleistocene terrace deposits occur at several elevations, and consist of poorly sorted conglomerates and coarse pebbly sandstones, highly lenticular and cross-bedded, dipping seaward at low angles.

STRUCTURE

Faults.

The most conspicuous structural feature is the Santa Cruz Island fault, dividing the Island lengthwise into two parts which are geologically quite unlike. No siliceous shale and almost no extrusive volcanic rocks appear south of the fault; on the other hand, no rocks older than the Middle Miocene volcanics are exposed north of it. The fault is a remarkably sharp break so that in many exposures there is almost no gouge. Movement has occurred after the deposition of the terrace material, causing a vertical displacement of the terrace which amounts to at least fifty feet, and is shown on the beach near Christy Ranch. Offset streams show a relative westward displacement of the north side.

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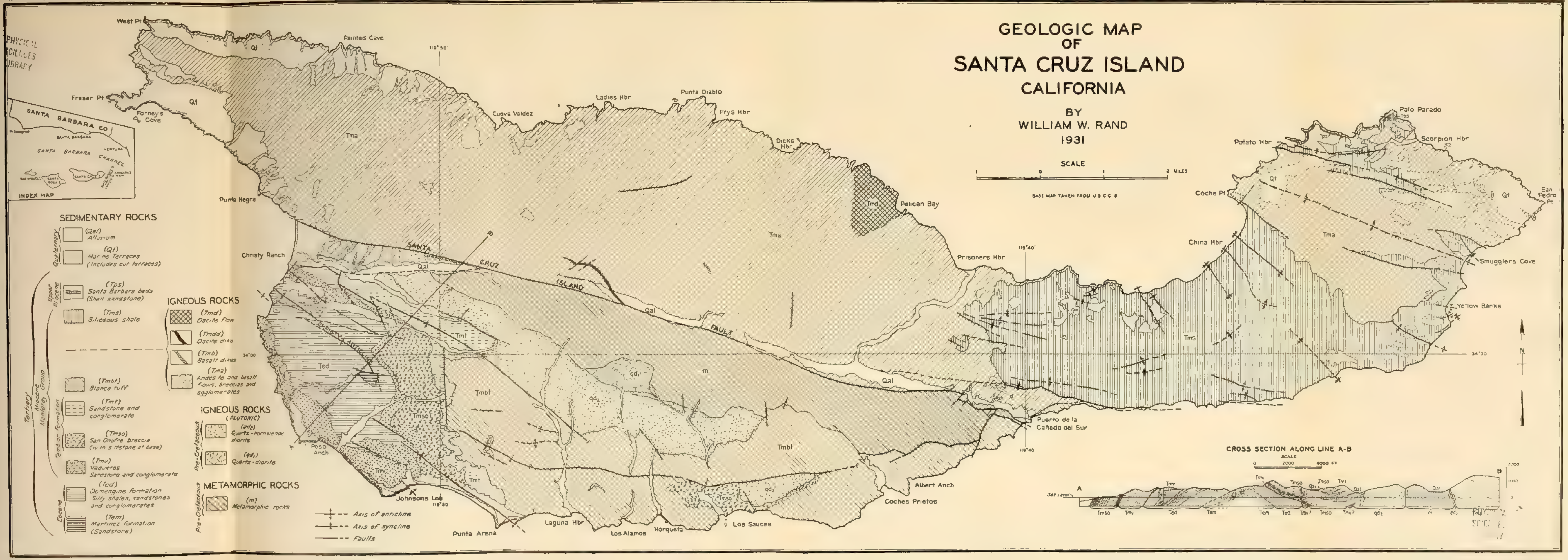
CALIFORNIA STATE DIVISION OF MINES
WALTER W. BRADLEY, STATE MINERALOGIST

GEOLOGIC BRANCH
OLAF P. JENKINS, CHIEF GEOLOGIST.



Other faults of lesser displacement roughly parallel the Santa Cruz Island fault on the south, and still others cross it at high angles near the Isthmus.

Folds.

The Christy anticline has been formed by folding which occurred after the deposition of the Eocene sediments, and again after the Miocene deposition; the later folding has produced a new axis in the Miocene slightly south of the axis in the Eocene. Folding or tilting has caused the Blanca tuff to dip southerly and has also increased the northerly dip of the volcanics so that the wider part of the Island somewhat resembles a large anticline. Several short, gentle folds are present in the shale of the Isthmus, and a longer fold crosses the volcanics of the eastern end.

7—84811

OIL FIELD DEVELOPMENT OPERATIONS

By R. D. Bush, State Oil and Gas Supervisor.

From December 28, 1930, to and including March 28, 1931, the following new wells were reported as ready to drill:

Company	Sec.	Twp.	Range	Well No.	Field
ALAMEDA COUNTY:					
A. M. Gilstrap	15	3	3	1	
FRESNO COUNTY:					
Milham Exploration Co.	28	21	17	25	Kettleman Hills
Pacific Western Oil Co.	28	21	17	14	Kettleman Hills
KERN COUNTY:					
Belridge Oil Co.	27	27	20	64-27	Belridge
Belridge Oil Co.	35	27	20	8-35	Belridge
Belridge Oil Co.	35	27	20	33-35	Belridge
Belridge Oil Co.	35	27	20	49-35	Belridge
Continental Oil Co.	36	27	20	Result 2	Belridge
General Petroleum Corp.	26	28	27	Sill 4	Kern River
General Petroleum Corp.	13	26	20	Lost Hills Two 1301	Lost Hills
C. C. M. O. Co.	8	32	23	89	Midway
General Petroleum Corp.	16	27	28	Heisen 14	Mt. Poso
General Petroleum Corp.	16	27	28	Heisen 29	Mt. Poso
Shell Oil Co.	27	28	29	Olcese 3-1	Round Mountain
Wicker & McCarter	19	28	29	1	Round Mountain
Alpine Oil Co., Ltd.	13	31	29	DiGiorgio 1	
C. C. M. O. Co.	31	25	28	Villard A-1	
Cumberland Oil Co.	16	26	18	Cumberland 1	
John B. Harding	5	10	10	2	
F. B. Langstroth	14	26	19	1	
Shell Oil Co.	32	30	29	Morris 1	
Union Oil Co.	21	28	20	Bacon 1	
Sy Wicker	12	30	28	6	
KINGS COUNTY:					
Petroleum Securities Co.	30	23	19	Burbank 1	Kettleman Hills
Standard Oil Co.	29	23	19	6	Kettleman Hills
Irma Investment Corp., Ltd.	7	23	20	Watson 1	
LOS ANGELES COUNTY:					
Standard Oil Co.	13	3	11	Emery 48	Coyote Hills
Ingalls Oil Co.	20	3	14	1	Lawndale
Allied Petroleum Corp.	19	4	12	Garrison 4	Long Beach
Columbia Oil Co., Ltd.	13	4	13	1	Long Beach
D. P. T. Petroleum, Ltd.	18	4	12	1	Long Beach
Dabney-Johnston Oil Corp.	29	4	12	84	Long Beach
Dabney-Johnston Oil Corp.	13	4	13	75	Long Beach
Davis Investment Co.	29	4	12	19	Long Beach
The Hancock Oil Co.	19	4	12	Signal 23	Long Beach
Highlin Oil Corp., Ltd.	30	4	12	1	Long Beach
F. H. Lathrap	29	4	12	2	Long Beach
M. & A. Oil Co., Ltd.	29	4	12	Painted Hills 3	Long Beach
McKeon Oil Co.	30	4	12	10	Long Beach
Moffatt & Campbell Petroleum Co., Ltd.	19	4	12	1	Long Beach
Shell Oil Co.	29	4	12	Stakemiller 9	Long Beach
Standard Leasing Co.	19	4	12	1	Long Beach
Electrological Petroleum Corp., Ltd.	6	3	16	Overman 1	Newhall
York-Smullin Oil Co.	13	3	16	6	Newhall
Barnsdall Oil Co.	28	2	15	Burks 7	Playa del Rey
Barnsdall Oil Co.	28	2	15	Burks 11	Playa del Rey
Birch-Royer Oil Co.	28	2	15	Lovell Comm. 1	Playa del Rey
Walter M. Crawford	28	2	15	3	Playa del Rey
Sam B. Herndon Oil Co., Ltd.	28	2	15	Herndon 2	Playa del Rey
Lubrite Oil Co. of California, Ltd.	28	2	15	2	Playa del Rey
Mack Oil Co., Ltd.	28	2	15	1	Playa del Rey
Donley McKeon	28	2	15	Donley McKeon 1	Playa del Rey

OIL FIELD DEVELOPMENT OPERATIONS—Continued.

Company	Sec.	Twp.	Range	Well No.	Field
LOS ANGELES COUNTY—Cont.					
Meier Oil Co., Ltd.	28	2	15	1	Playa del Rey
The Ohio Oil Co.	21	2	15	Recreation Gun Club 10	Playa del Rey
Senator Oil Co., Ltd.	28	2	15	2	Playa del Rey
Transcalifornia Oil Co., Ltd.	28	2	15	1	Playa del Rey
Union Oil Co.	27	2	15	King Vidor 1	Playa del Rey
Union Oil Co.	28	2	15	Townsite 8	Playa del Rey
Union Oil Co.	28	2	15	Townsite 9	Playa del Rey
Venice Pacific Oil Co., Ltd.	28	2	15	3	Playa del Rey
Wedol Petroleum Co.	28	2	15	1	Playa del Rey
S. S. Wortley No. 3	28	2	15	3	Playa del Rey
Golden State Exploration Co.	7	3	13	1	Rosecrans
Tureco Oil Co., Ltd.	8	3	13	Community 1	Rosecrans
Union Oil Co.	6	3	11	Bell 22	Santa Fe Springs
Union Oil Co.	6	3	11	Bell 62	Santa Fe Springs.
E. S. Cone	6	4	14	W. K. Kellogg & F. F. Burdick 1	Torrance
Corniel Oil Corp., Ltd.	31	3	14	1	Torrance
Hermosa Exploration Co., Ltd.	6	4	14	1	Torrance
Westwood Oil Producers Co., Ltd.	6	4	14	1	Torrance
Huntington Central Oil Co.	34	1	11	1	----------
The Mesmer City Realty Co., Ltd.	24	2	15	1	----------
Lyle W. Rucker	26	1	17	1	----------
Staple Oil Co., Ltd.	24	3	15	Community 1	----------
The Texas Co.	4	2	12	Repetto Hills 1	----------
York-Smullin Oil Co.	29	4	13	1	----------
ORANGE COUNTY:					
Standard Oil Co.	18	3	10	Murphy-Coyote 106	Coyote Hills
Standard Oil Co.	19	3	10	Murphy-Coyote 107	Coyote Hills
Standard Oil Co.	24	3	11	Emery 49	Coyote Hills
W. F. Baldwin Oil Co., Ltd.	2	6	11	Golden Star 1	Huntington Beach
Archie L. Fietz	10	6	11	1	Huntington Becah
Stevenson Bros. Drilling Co.	35	5	11	La Bolsa Tile 1	Huntington Beach
E. C. Johnson & John F. Dietzel	32	3	9	Irwin 1	Richfield
Gieck Oil Corp., Ltd.	20	5	11	Wilson 1	----------
RIVERSIDE COUNTY:					
Frank Beck	1	3	1	1	----------
SAN MATEO COUNTY:					
Easton-Monell	25	3	6	1	----------
SANTA BARBARA COUNTY:					
El Capitan Oil Co.	5	4	30	173-1	Capitan
Barnsdall Oil Co.	15	4	29	Luton-Bell 18	Elwood
Joe Ferring	10	4	29	1	Elwood
General Petroleum Corp.	32	5	30	Erburu 10	----------
Irvine Oil Co., Ltd.	27	4	27	1	----------
George W. Johnson	------	4	28	Duncan 1-A	----------
Palisades Petroleum Corp.	28	4	27	Meigs 3	----------
Sunset Pacific Oil Co.	12	4	29	Pomatto 1	----------
TULARE COUNTY:					
Grand View Oil Co., Ltd.	8	23	28	1	----------
George C. Knoop	20	22	27	1	----------
C. E. Pettingall	15	22	27	1	----------
VENTURA COUNTY:					
Ross and Associates	12	3	20	10	Bardsdale
Bardeen Petroleum Co., Ltd.	13	4	19	1-B	Piru
Continental Oil Co.	23	3	24	Grubb 1	Rincon
Honolulu Oil Corp., Ltd.	7	3	24	56-1	Rincon
Belga-American Oil Co., Ltd.	22	4	21	1	Santa Paula
Associated Oil Co.	23	3	23	McGonigle 9	Ventura
Shell Oil Co.	21	3	23	Taylor 68	Ventura
Magu Syn., Inc., Ltd.	17	1	21	1	----------

SPECIAL ARTICLES

Detailed technical reports on special subjects, the result of research work or extended field investigations, will continue to be issued as separate bulletins by the Bureau, as has been the custom in the past.

Shorter and less elaborate technical papers and articles by members of the staff and others are published in each number of 'Mining in California.'

These special articles cover a wide range of subjects both of historical and current interest; descriptions of new processes, or metallurgical and industrial plants, new mineral occurrences, and interesting geological formations, as well as articles intended to supply practical and timely information on the problems of the prospector and miner, such as the text of the new laws and official regulations and notices affecting the mineral industry.

ADMINISTRATIVE

WALTER W. BRADLEY, State Mineralogist

Personnel.

There have been no changes nor additions of personnel to be noted during the past three months.

New Publications.

Mining in California (quarterly), October 1930, being Chapter 4 of the State Mineralogist's Report XXVI. Price 25 cents. Contains reports on the mineral resources of Butte, Kings, and Tulare counties; "Preliminary Report on the Geology of Southwestern Mono County"; also "Biennial Report of the State Mineralogist" to the Governor; a special article on "Our Decreasing Gold Supply."

Commercial Mineral Notes, Nos. 94, 95, 96, January, February, March, 1931, respectively. These 'notes' contain the lists of 'mineral deposits wanted' and 'mineral deposits for sale,' issued in the form of a mimeographed sheet, monthly. It is mailed free to those on the mailing list for MINING IN CALIFORNIA.

As an evidence of the interest in mines and minerals now showing considerable activity, this mimeographed 'sheet' has had to be expanded to two pages for the current issues.

Mails and Files.

The Division of Mines maintains, in addition to its correspondence files and library, a mine file, which includes original reports on the various mines and mineral properties of all kinds in California.

During each quarterly period there are several thousand letters received and answered at the San Francisco office alone, covering almost every phase of prospecting, mining and developing mineral deposits, reduction problems, marketing of refined products, and mining law. In addition to this, hundreds of oral questions are answered daily, both at the main office and the district offices, for the many inquirers who come in for personal interviews and to consult the files and library.

MINERALS AND STATISTICS

Statistics, Museum, Laboratory

HENRY H. SYMONS, Statistician and Curator

STATISTICS

California counties produce commercially, as for some years past, more than 50 different mineral substances, the total value of which for 1930 was estimated at $347,797,000 (see January issue MINING IN CALIFORNIA).

At present (April, 1930) reports are in hand for most of the producers. Data for several substances are now complete and have been compiled, being presented herewith.

Information at hand indicates that there was no production during 1930 of the following substances, which have at one time or another in the past been active here: antimony, arsenic, bismuth, fluorspar, lithia, manganese ore, mica, molybdenum, serpentine, shale oil, strontium, tin, titanium, and zinc. There was production by a single operator in each of the following: andalusite, asbestos, bromine, cyanite, iron ore, mineral paint, potash, and tin.

BARYTES

Commercial shipments of crude barytes in California for 1930 amounted to a total of 19,783 short tons valued at $133,107 f.o.b. rail-shipping point. This was a decrease in both quantity and value from the figures of 1929 which were 26,796 short tons and $168,829. The 1930 yield came from two properties in San Bernardino County and a single property each in Inyo, Mariposa, Nevada, and Santa Barbara counties.

More than half of the total tonnage of barytes utilized in the United States is taken in the manufacture of lithopone, which is a chemically-prepared white pigment containing approximately 70% barium sulphate and 30% zinc sulphide. This is one of the principal constituents of chemicals. Being neutral, clay does not have an injurious effect upon other constituents used in the manufacture of such articles. In paper making, clay is used as a filler in news and similar grades, and as a coater or glazer in the more highly-finished art papers. A large part of the china clay used in the United States is imported from England.

BITUMINOUS ROCK

This material is essentially an uncemented sandstone which is saturated with and held together by a natural asphaltic constituent, probably the residue from the evaporation of a crude petroleum deposit. Bituminous rock is still used to a limited extent for road dressing in those districts adjacent to available deposits, though the manufacture of asphalt at the oil refineries has almost entirely super-

seded the direct use of the native material. Some of the Santa Cruz County production is put on the market as a material which can be laid cold. This material is especially applicable and valuable for patch jobs.

Shipments of bituminous rock were made from quarries in Santa Barbara and Santa Cruz, totaling 8525 tons valued at $36,075 f.o.b. railroad. This was an increase in both quantity and value over the 1929 output, which was 3320 tons and $14,360.

BORATES

During 1930 there was produced in California a total of 215,986 tons of borate materials, compared with 162,059 tons for the year 1929. The material shipped during the year included the new sodium borates, kernite (rasorite), kramerite and some colemanite from Kern County; also crystallized borax prepared by evaporation of brines at Searles Lake in San Bernardino County and Owens Lake in Inyo County.

As the crude ore is not sold as such, but is almost entirely calcined before shipping to the refinery for conversion into the borax of commerce, and because of the fact that the material varied widely in boric acid content, we have recalculated the tonnage to a basis of 40 per cent, A. B. A. This is approximately the average A. B. A. content of the colemanite material after calcining, and also of the crystallized borax obtained from evaporation of the lake brines. Recalculated as above, the 1930 production totaled 209,869 short tons valued at $3,686,817, being an increase in both quantity and value over the 1929 output, which was 144,678 tons worth $3,312,085.

Colemanite is a calcium borate, and the material mined is shipped to seaboard chemical plants for refining. The latest development in the borax industry is the finding in quantity and opening up of a new borate mineral which has now supplanted colemanite in much the same way that colemanite deposits displaced the borax industry in the desert playas or dry lakes, some forty years ago. This new mineral is 'kernite' (or 'rasorite'), a sodium borate with a smaller water-of-crystallization content than the 'borax' of commerce, so that when recrystalized to borax, the resulting product has an increased weight over the original material. These deposits are being mined by the Pacific Coast Borax Company in southeastern Kern County.

Refined 'borax' (sodium tetraborate) is used in making the enameled coating for cast-iron and steelware employed in plumbing fixtures, chemical equipment, and kitchen utensils. It is also a constituent of borosilicate glasses which are utilized in making lamp chimneys, baking dishes, and laboratory glassware. Other important uses of borax are in the manufacture of laundry and kitchen soaps, in starch, paper sizing, tanning, welding, and in the preparation of boric acid, which is employed as an antiseptic and in preserving meats. Among the newer uses for borax is its employment in the preserving of citrus fruits by washing them in a solution of borax, which closes the pores of the skin. The application of this process is increasing in California and Florida. Another is as a preservative of wood, in addition to which borax, being noninflammable, renders it fireproof.

CEMENT

Cement is the most important single structural material in the mineral output of California. During 1930 there was produced a total of 9,831,938 barrels of cement valued at $14,575,731 f.o.b. plant, being a decrease in both quantity and value from the preceding year. The 1929 output was 12,794,729 barrels valued at $21,038,565 or an average of $1.64 per barrel. The average value per barrel for 1930 was $1.48.

The 1930 production came from ten plants operating in nine counties and employing a total of 1904 men. Two plants were in operation in San Bernardino County and a single plant in each of the following counties: Calaveras, Contra Costa, Kern, Merced, Riverside, San Benito, San Mateo and Santa Barbara.

There has been an interesting parallelism in the growth of the Portland cement and the crushed rock, sand and gravel industries in California. The use of concrete has been a most important development in structural work during the last 20 or 30 years, and has made possible the building of such great monolithic structures as our irrigation and hydro-electric power dams, as well as highway pavements and skyscraper office buildings.

FELDSPAR

Feldspar was produced by five operators in three counties (Kern, Riverside, and San Diego) in California during 1930 to the amount of 5014 short tons valued at $35,654. This was a decrease in both quantity and value as compared with the 1929 figures which were 13,327 tons and $78,404.

The requirements of the pottery trade demand that in general the percentage of free silica associated with the feldspar be less than 20 per cent, and in some cases the potters specify less than 5 per cent. An important factor, also, is the iron-bearing minerals frequently present in pegmatites and granites, such as biotite (black mica), garnet, hornblende and black tourmaline. Feldspar for pottery uses should be practically free of these. The white, potash-mica, muscovite, is not particularly objectionable except that being in thin, flexible plates, it does not readily grind to a fineness required for the feldspar.

GYPSUM

During 1930 there were shipments of gypsum in California, amounting to 116,865 short tons valued at $243,507, coming from two properties each in Fresno and Riverside counties and one each in Imperial and Kern counties. This was a decrease in both quantity and value compared with the 1929 output, which was 140,844 tons and $396,951.

Uses.

The most important use of gypsum from the quantity standpoint is in the calcined form where it is utilized in the manufacture of various hard-wall plasters and plaster board. As plaster of Paris, it plays a very important part in surgical work. Approximately 2%, by weight, raw gypsum is added in the manufacture of Portland cement just before the final grinding. In this application, the gypsum acts as a

retarder to the set of the cement. The use of gypsum tile for non-bearing fireproof partitions, stairway and elevator enclosures, and the protection of steel columns, girders, and beams, has increased greatly.

Keene's cement is a gypsum product, calcined to complete dehydration, and an accelerator added such as alum, potassium, sulphate, borax, aluminum sulphate.

Land plaster may be applied to the soil by drilling, or scattered in the hill, or it may be sowed broadcast, in quantities ranging from 200 to 500 pounds to the acre.

LIME

In California during 1930 there was an output of lime to the amount of 47,662 tons valued at $452,084, coming from two plants in Santa Cruz County and one each in El Dorado, Inyo, San Benito, San Bernardino, Siskiyou, and Tuolumne counties. The above amount was an increase in both quantity and value over the 1929 production, which was 42,834 tons worth $417,101.

So far as we have been able to segregate the data, these figures include mainly only such lime as is used in building operations; though they do include a small proportion of calcined lime employed in agriculture and the chemical industries, the figures for which were not separable. A portion is hydrated lime. Limestone utilized in sugar making, for smelter flux, as a fertilizer, and other special industrial uses, are classified under 'Industrial Materials.' That consumed in cement manufacture is included in the value of cement.

LIMESTONE

'Industrial' limestone was produced by 16 operators in 9 counties in California during 1930 to the amount of 169,477 short tons valued at $508,751. Although there was a slight increase in amount the total value was less than that of 1929 figures, which were 168,315 tons and $557,617.

The amount here given does not include the limestone used in the manufacture of cement nor for macadam and concrete, nor of lime for building purposes; but accounts for that utilized as a smelter and foundry flux, for glass and sugar making, and other special chemical and manufacturing processes. It also includes that utilized for fertilizers (agricultural 'lime'), 'roofing gravel,' paint and concrete filler, whiting for paint, putty, kalsomine, terrazzo, paving dust, chicken grit, carbon dioxide gas, 'paving compound,' facing dust for concrete pipe, also for rubber and magnesite mix. The material from Ventura County was a marl and that from San Mateo and Santa Clara counties was shells dredged from San Francisco Bay, all of which was ground and used for agricultural purposes or poultry grit. Of the total 'industrial' limestone produced in 1930, approximately 29,823 tons valued at $134.-618 were used for agricultural purposes.

Distribution of 1930 output of limestone was as follows:

County	*Amount*	*Value*
El Dorado	88,869	$205,225
Santa Cruz	11,405	46,925
Mendocino, San Bernardino, San Mateo, Santa Clara, Tulare, Tuolumne, Ventura*	69,203	256,601
Totals	169,477	$508,751

* Combined to conceal the output of operators in each.

MAGNESITE

The production of magnesite in California during 1930 amounted to a total of 38,681 tons of crude ore valued at $388,472. Only a small part of it was sold crude, however, as it was practically all shipped in the calcined form. The reports at hand show a total of 14,653 tons shipped calcined valued at $441,780 rail shipping point; of this about 35% was dead-burned and periclase for refractory purposes, the balance going to the plastic trade. This material came from San Benito, Santa Clara, Stanislaus and Tulare counties with a single producer in each. From 2 to 2½ tons of crude material are mined to make one ton of calcined.

The 1930 output showed a decrease in both quantity and value from the 1929 figures which were 47,269 tons crude valued at $488,014. The average of the values for crude reported for 1930 is $10.04 per ton compared with $10.32 in 1929, $11.00 in 1928 and $12.50 in 1927.

Uses.

The principal uses include: Refractory linings for basis open-hearth steel furnaces, copper reverberatories and converters, bullion and other metallurgical furnaces; in the manufacture of paper from wood pulp; and in structural work, for exterior stucco, for flooring, wainscoting, tiling, sanitary, kitchen and hospital finishing, etc. In connection with building work it has proved particularly efficient as a flooring for steel railroad coaches, on account of having greater elasticity and resilience than 'Portland' cement. For refractory purposes, the magnesite is 'dead-burned'—*i. e.*, all or practically all of CO_2 is expelled from it. For cement purposes it is left 'caustic'—*i. e.*, from 2% to 10% of CO_2 is retained. When dry caustic magnesite is mixed with a solution of magnesium chloride ($MgCl_2$) in proper proportions, a very strong cement is produced, known as oxychloride or Sorel cement. It is applied in a plastic form, which sets in a few hours, as a tough, seamless surface. It has also a very strong bonding power, and will hold firmly to wood, metal, or concrete as a base. It may be finished with a very smooth, even surface, which will take a good wax or oil polish. As ordinarily mixed there is added a certain proportion of wood flour, cork, asbestos, or other filler, thereby adding to the elastic properties of the finished product. Its surface is described as 'warm' and 'quiet' as a result of the elastic and nonconducting character of the composite material. The cement is frequently colored by the addition of some mineral pigment to the materials before mixing as cement.

For refractory purposes the calcined magnesite is largely made up into bricks similar to fire-brick for furnace linings. It is also used unconsolidated, as 'grain' magnesite. For such, an iron content is desirable, as it allows a slight sintering in forming the brick. Dead-burned, pure magnesia can not be sintered except at very high tempertures; and it has little or no plasticity, so that it is hard to handle. Its plasticity is said to be improved by using with it some partly calcined or caustic magnesite. Heavy pressure will bind the material sufficiently to allow it to be sintered.

A coating of crushed magnesite is laid on hearths used for heating steel stock for rolling, to prevent the scale formed from attacking the fire-brick of the hearth.

Pure magnesite which is fused to a hard flint-like mass called 'artificial periclase', will not shrink with additional heat and is used as a refractory for high temperatures.

Before the World War, practically all of the domestic output of caustic magnesite was used in the manufacture of pulp and paper. For this purpose calcined dolomite is now used. The use of dolomite instead of magnesite by the paper manufacturers began during the war when the price of magnesite was very high. Dolomite was found to be a good substitute for magnesite in the bisulphite process of paper making and so its use has continued.

PYRITES

A total production of 39,958 short tons of pyrite valued at $194,228 was reported shipped in California during 1930 from properties in Alameda and Shasta counties. This was a decrease both in quantity and value from the 1929 figures which were 79,169 tons and $363,717. This material was mostly used in the manufacture of sulphuric acid for explosives and fertilizers. Some iron sulphate has been produced previously and was utilized directly in the preparation of an agricultural fertilizer and insecticide. The sulphur content ranged up to 50.8 per cent S.

This does not include the large quantities of pyrite, chalcopyrite, and other sulphides which are otherwise treated for their valuable metal contents. Some sulphuric acid is annually made as a by-product in the course of roasting certain tonnages of Mother Lode auriferous concentrates while under treatment for their precious metal values.

SALT

Most of the salt production in California is obtained by evaporation of water of the Pacific Ocean, plants being located on the shores of San Francisco, Monterey, and San Diego bays, and at Long Beach. Additional amounts are derived from lakes and lake beds in the desert regions, mainly in Inyo, Kern and San Bernardino counties, and evaporation of alkaline lake water in Modoc County. A small amount of valuable medicinal salts is obtained by evaporation of the water of Lake Mono, Mono County.

During 1930 in California there was an output of 347,945 short tons of salt valued at $1,167,487, being a decrease in both quantity and value from the 1929 figures, which were 392,039 short tons and $2,665,436. There were thirteen plants operating in 1930, three of which were in Alameda, two each in San Bernardino and San Mateo, and one each in Inyo, Kern, Los Angeles, Modoc, Monterey and San Diego.

The average value reported for salt produced in California in 1930 was $3.36 per ton f.o.b. plant, as compared with $6.80 in 1929 and $3.00 in 1928.

SILICA (SAND and QUARTZ)

We combine these materials because of the overlapping roles of vein quartz which is mined for use in glass making and as an abrasive, and that of silica sand which, although mainly utilized in glass manufacture, also serves as an abrasive. Both varieties are also utilized to some extent in fire-brick manufacture.

A portion of the tonnage of vein quartz in California in 1916 and 1917 was employed in the preparation of ferro-silicon by the electric furnace. At present, some is utilized as a foundry flux, and for steel-casting molds. A portion of the silica sold (both sand and quartz) is also used in glazes for porcelain, pottery and tile, and in the body of the ware to diminish shrinkage; and some of the sand for the preparation of sodium silicate ('water glass'). Manufacturers of paint use finely-ground silica, which forms as much as one-third of the total pigment in some paints. For certain purposes finely-ground crystalline material is superior in paints to other materials because of the angularity of the grains, which makes them adhere more firmly to the article painted and after wear afford a good surface for repainting. The same angularity makes artifically comminuted crystalline quartz superior to natural sand for use in wood fillers. It is also preferable for soaps and polishing powders. Part of the 1925 output was used for roofing and stucco-dash granules.

We do not include under this heading such forms of silica as: quartzite, sandstone, flint, tripoli, diatomaceous earth, nor the gem forms of 'rock crystal,' amethyst, and opal. Each of these has various industrial uses, which are treated under their own designations.

The production of silica in California during 1930 amounted to 17,803 short tons valued at $71,380, coming from eight properties in seven counties, viz: Contra Costa, El Dorado, Inyo, Monterey, Placer, Riverside, and San Diego. This was a decrease in both quantity and value from the 1929 output which was 18,686 tons worth $79,210. Of the above total 10,985 tons were glass sand and 6817 tons of vein and boulder quartz. For making the higher grades of glass, most of the sand is imported from Belgium. Belgium sand has also displaced local material in the manufacture of sodium silicate ('water glass'). There are various deposits of quartz in California which could be utilized for glass making, but to date they have not been so used owing to the cost of grinding and the difficulty of preventing contamination by iron while grinding.

Silica sand has been produced in the following counties of the state: Alameda, Amador, Contra Costa, El Dorado, Imperial, Los Angeles, Mariposa, Mono, Monterey, Orange, Placer, Riverside, San Diego, San Joaquin and Tulare, the chief centers being Amador, Monterey and Los Angeles counties. The industry is of limited importance, so far, because of the fact that much of the available material is not of a grade which will produce first-class colorless glass; for such, it must be essentially iron-free. Even a fractional per cent of iron imparts a green color to the class.

SODA

The production of sodium salts in California in 1930 included: Soda ash, trona, caustic soda and bicarbonate from plants at Owens

Lake, Inyo County, and trona ('sesqui-carbonate,' a double salt of Na_2CO_3 and Na_2CO_3 and $NaHCO_3$) from Searles Lake, San Bernardino County. There were no shipments of salt cake (sulphate) from the Carrizo Plains, San Luis Obispo County, in 1930.

The total for the year amounted to 90,122 tons valued at $1,627,344 compared with the 1929 figures which were 90,649 tons and $1,838,657.

The dense ash and bicarbonate were used mainly in the manufacture of soap, glass, paper, oil refining, sugar refining, and chemicals; and the trona for metallurgical purposes.

Sodium compounds to some extent replace potassium compounds, in glass and soap making, in photography, in match making, in tanning, sugar refining, and in the manufacture of cyanide for extracting gold and silver from their ores.

MUSEUM

The museum of the State Division of Mines possesses an exceptionally fine collection of rocks and minerals of both economic and academic value. It ranks among the first five of such collections in North America; and contains not only specimens of most of the known minerals found in California, but much valuable and interesting material from other states and foreign countries as well.

Mineral specimens suitable for exhibit purposes are solicited, and their donation will be appreciated by the State Division of Mines as well as by those who utilize the facilities of the collection.

The exhibit is daily visited by engineers, students, business men, and prospectors, as well as tourists and mere sightseers. Besides its practical use in the economic development of California's mineral resources, the collection is a most valuable educational asset to the State and to San Francisco.

LABORATORY

Frank Sanborn, Mineral Technologist

Gold prospecting has been the favorite choice of the ore searchers for the past several months. As has been stated before, certain minerals seem, at times, to stand out as preferred among the prospectors. Radium-bearing, rare-earth, beryllium and many other minerals have had their popular run. We are now receiving approximately ten samples a day with requests that they be tested for the presence of gold and silver.

Today, May 4th, a sample was received from Somerton, Imperial County, that has a gold value of nearly $200 a ton. This sample consists of quartz with considerable malachite, the green carbonate of copper, and limonite, the yellow oxide of iron. Little or no gold could be seen in panning.

A few weeks ago a quartz sample from Siskiyou County gave no gold colors in panning, but assaying proved the ore to be worth over twenty dollars a ton.

Valuable gold mines, yielding an ore that did not contain grains of gold sufficiently large to be seen in panning, have been found in the past, and it is reasonable to believe that such mines yet remain uncovered and are to be found by some earnest prospector.

LIBRARY

HERBERT A. FRANKE, Librarian

In addition to the numerous standard works, authoritative information on many phases of the mining and mineral industry is constantly being issued in the form of reports and bulletins by various government agencies.

The library of the Division of Mines contains some six thousand selected volumes on mines, mining and allied subjects, and it is also a repository for reports and bulletins of the technical departments of Federal and state governments and of educational institutions, both domestic and foreign.

It is not the dearth of the latter publications, but rather a lack of knowledge of just what has been published and where the reports may be consulted or obtained, that embarasses the ordinary person seeking specific information.

To assist in making the public acquainted with this valuable source of current technical information, MINING IN CALIFORNIA contains under this heading a list of all books and official reports and bulletins received, with names of publishers or issuing departments.

Files of all the leading technical journals will be found in the library, and county and State maps, topographical sheets and geological folios. Current copies of local newspapers published in the mining centers of the State are available for reference.

The library and reading room are open to the public during the usual office hours, when the librarian may be freely called upon for all necessary assistance.

OFFICIAL PUBLICATIONS RECEIVED

Governmental.

U. S. Geological Survey:

Bulletins:

813—Mineral Resources of Alaska, 1928. By P. S. Smith and others.
821-B—A Geologic Study of the Madden Dam Project, Alhajuela, Canal Zone. By F. Reeves and C. P. Ross.
821-C—Iron Ore on Canyon Creek, Fort Apache Indian Reservation, Arizona. By E. F. Burchard.
822—Contribution to Economic Geology, 1930. Part II, Mineral Fuels.
823—Bibliography of North American Geology, 1919–1928. By M. Nickles.
826—Names and Definitions of the Geologic Units of California. By M. G. Wilmarth.

Water-Supply Papers:

622—Part II, South Atlantic Slope and Eastern Gulf of Mexico Basins.
633—Part XII, North Pacific Slope Drainage Basins. B. Snake River Basin.
637-B—Preliminary Report on the Ground-Water Supply of Mimbres Valley, New Mexico. By W. N. White.
637-C—Water-Power Resources of the McKenzie River and its Tributaries, Oregon. By B. E. Jones and H. T. Stearns.
644—Part IV, St. Lawrence River Basin.
649—Part IX, Colorado River Basin.
650—Part X, The Great Basin.

Pamphlets:

Platinum, Hints for Prospectors.

U. S. Bureau of Mines:

Bulletins:

327—Potash Bibliography to 1928. (Annotated.) By J. F. T. Berliner.
328—Greensand Bibliography to 1930, (Annotated), with a Chapter on Zeolite Water Softeners. By R. N. Shreve.
330—Ventilation of the Large Copper Mines of Arizona. By G. E. McElroy.
331—Permissible Methane Detectors. By A. B. Hooker, W. J. Fene, and R. D. Currie.
333—Refining of Light Petroleum Distillates. By H. P. Rue and R. H. Espach.
334—A Study of Refractories Service Conditions in Boiler Furnaces. By R. A. Sherman.

Technical Papers:

480—Intensities of Odors and Irritating Effects of Warning Agents for Inflammable and Poisonous Gases. By S. H. Katz and E. J. Talbert.
481—Re-Treatment of Mother Lode (California) Carbonaceous Slime Tailings. By E. S. Lever and J. A. Woolf.
482—Toxic Gases from 60 Per Cent Gelatin Explosives.
483—Re-Forming Natural Gas. By W. W. Odell.
484—Analyses of Wyoming Coals. By C. E. Dobbin.
485—Timbering Regulations in Certain Coal Mines of Pennsylvania, West Virginia, and Ohio. By J. W. Paul, J. G. Calverley, and D. L. Sibray.
486—Chemistry of Leaching Bornite. By J. D. Sullivan.
487—Chemistry of Leaching Covellite. By J. D. Sullivan.
495—Coke-Oven Accidents in the U. S. During the Calendar Year 1929. By W. W. Adams and L. Chenoweth.

Mineral Resources of the United States:

Mercury in 1929. By P. M. Tyler.
Potash in 1929. By A. T. Coons.
Slate in 1929. By O. Bowles and A. T. Coons.
Salt, Bromine, and Calcium Chloride in 1929. By A. T. Coons.
Rare Metals. By P. M. Tyler and A. V. Petar.
Asbestos in 1929. By O. Bowles and B. H. Stoddard.
Sulphur and Pyrites in 1929. By R. H. Ridgway.
Mineral Resources of the U. S. in 1929. (Preliminary Summary.)
Silver, Copper, Lead, and Zinc in the Central States in 1929. By J. P. Dunlop and H. M. Meyer.
Natural Gas in 1929. By G. R. Hopkins and H. Backus.
Lime in 1929. By A. T. Coons.
Stone in 1929. By A. T. Coons.
Talc and Soapstone in 1929. By O. Bowles and B. H. Stoddard.
Barite and Barium Products in 1929. By R. M. Santmyers and B. H. Stoddard.
Lead in 1929. By E. W. Pehrson.
Secondary Metals in 1929. By J. P. Dunlop.
Chromite in 1929. By L. A. Smith.

Petroleum Field Office:

Recent Articles on Petroleum and Allied Substances:

October, 1930.
November, 1930.
December, 1930.
January, 1931.

Report of Investigations:

3020—Influence of Washing Coal on Coke Properties and on Gas and By-Product Yields. By A. C. Fieldner.
3050—Leaching Copper Ores: Advantages of Wet-Charging. By John D. Sullivan and Alfred P. Towne.

3056—A Device for Determining Work Input to a Laboratory Ball Mill. By John Gross and Stuart R. Zimmerley.

3059—Development and Production History on the Salt Flat and Other Fault Fields of East Central Texas. By H. B. Hill, E. V. H. Bauserman, and C. B. Carpenter.

3060—Rock-Dusting a Pennsylvania Coal Mine. By C. W. Owings.

3061—A Study of the Properties of Polyhalite Pertaining to the Extraction of Potash. Part III. Calcination of Polyhalite in a Laboratory-Sized Rotary Kiln. By Loyal Clarke, J. M. Davidson, and H. H. Storch.

3064—Oxygen as an Aid in the Dissolution of Silver by Cyanide from Various Silver Minerals. By E. S. Leaver, J. A. Woolf, and N. K. Karchmer.

3069—Official Changes in the Active List of Permissible Explosives and Blasting Devices for January, 1931.

3075—Consumption of Explosives in November, 1930. By W. W. Adams and L. S. Gerry.

3080—The Production of High-Manganese Slag in the Electric Furnace. By T. L. Joseph, C. E. Wood, and E. P. Barrett.

3081—New Manganese-Silicon Alloys for the Deoxidation of Steel. By C. H. Herty, Jr., and G. R. Fitterer.

3082—Coal-Mine Fatalities in December, 1930.

3087—Consumption of Explosives in December, 1930. By W. W. Adams and L. S. Gerry.

3090—Coal-Mine Fatalities in January, 1931. By W. W. Adams and L. Chenoweth.

3092—Twenty-second Semiannual Motor Gasoline Survey. By A. J. Kraemer and E. C. Lane.

Information Circulars:

6382—Mine Ventilation in the Coeur D'Alene Mining District. By G. E. McElroy.

6385—Nitrogen and Its Compounds. By Bertrand L. Johnson.

6389—Platinum. By Paul M. Tyler and R. M. Santmyers.

6391—Diatomite. By Paul Hatmaker.

6394—Milling Methods at the Hurley Plant of the Nevada Consolidated Copper Co., Hurley, New Mexico. By Fred Hodges.

6397—Mining Methods of the Ducktown Chemical and Iron Co., Mary Mine, Isabella, Tenn. By Vern L. Kegler.

6399—Construction of the Wachusett-Coldbrook Tunnels. By Douglas C. Corner.

6402—Mining Methods and Costs at the Spring Hill Mine, Montana Mines Corporation, Helena, Mont. By A. L. Pierce.

6404—Milling Methods and Costs at the Copper Queen Concentrator of the Phelps Dodge Corporation, Bisbee, Ariz. By E. Whittenau and W. B. Cramer.

6405—Mining and Crushing Methods and Costs at the Monocacy Quarry of John T. Dyer Quarry Co., Monocacy, Pa., By Joseph A. Conway.

6406—Magnesium Compounds (other than magnesite). By Paul M. Tyler.

6407—Mining Methods of the Bunker Hill and Sullivan Mining and Concentrating Co., Kellogg, Idaho. By U. E. Brown.

6408—Milling Methods and Costs at the Homestake Mine, Lead, S. Dak. By Allan J. Clark.

6410—Mining by the Top-Slicing Method, with Some Notes on Sublevel Caving. By Charles F. Jackson.

6419—Mine Explosion, Mine Fires, and Miscellaneous Accidents in the United States During the Fiscal Year Ended June 30, 1930. By D. Harrington and C. W. Owings.

6420—Mining, Treatment Methods and Costs, Menantico Sand and Gravel Co., Millville, N. J. By Hugh Haddow, Jr.

6421—Method and Cost of Dredging Sand and Gravel by the Ohio River Sand Co., Louisville, Ky. By J. Hamilton Duffy.

6429—Method and Cost of Recovering Quicksilver from Low-Grade Ore at the Reduction Plant of the Sulphur Bank Syndicate, Clearlake, Calif. By Worthen Bradley.

6439—Effect on Workers of Air Conditions. By R. R. Sayers.

6440—Mining Methods and Practices at the United Verde Copper Mine, Jerome, Arizona. By T. W. Quayle.
6441—Geophysical Abstracts. No. JXI. By F. W. Lee.
6445—Resistivity Measurements Upon Artificial Beds. By Joel H. Swartz.
6452—Geophysical Abstracts. No. XXII. By Frederick W. Lee.
6461—Geophysical Abstracts. No. XXIII. By Frederick W. Lee.

Holmes Safety Chapter Notes, March, 1931.

U. S. Department of Commerce:

Bureau of Foreign and Domestic Commerce:

Trade Information Bulletins:

599—The Marketing of Manganese Ore.
624—The Marketing of Antimony.
631—The Marketing of Mercury.
643—The Marketing of Tungsten Ores and Concentrates.
655—Markets for Building Materials. Part 1, Canada and Newfoundland.
660—Markets for Building Materials. Part 2, Mexico, Central America and the West Indies.
685—The Marketing of Nickel.

Domestic Commerce Series:

6—Market Research Agencies.

Trade Promotion Series:

95—International Trade in Mica. By J. Ulmer.
105—The Coal Industry of the World. By H. M. Hoar.

Monthly Summary of Foreign Commerce of the U. S.:

Part 1, November,1930.
2, November, 1930.
1, December, 1930.
2, December, 1930.
1, January, 1931.
2, January, 1931.

Coast and Geodetic Survey:

Serial No. 483—U. S. Earthquakes.
503—Seismological Report, October, November, December, 1927.

U. S. Board of Engineers for Rivers and Harbors:

Annual Report of the Chief of Engineers, U. S. Army. Parts 1 and 2, 1930.

U. S. Treasury Department:

Document No. 3025—Annual Report of the Director of the Mint for the Fiscal Year Ended June 30, 1930, Including Report on the Production of the Precious Metals During the Calendar Year 1929.

Alabama Geological Survey:

Report of Progress for the Fiscal Years 1926–1930. By W. B. Jones.
Bull. 40—Gold Deposits of Alabama, and Occurrences of Copper, Pyrite, Arsenic and Tin. By G. I. Adams.
Bull. 41—Ochers of Alabama. By J. Barksdale.

Arkansas Geological Survey:

Bull. 4—St. Peter and Older Ordovician Sandstones of Northern Arkansas. By A. W. Giles.
Stream Gaging Report 1—Stream Gaging in Arkansas from 1857 to 1928. By W. S. Frame.

California State Bureau of Commerce:

Commercial and Industrial Organizations of California, 1930.

California Fish and Game:

Vol. 16, No. 4.

California State Division of Water Resources:

Bull. 28-A—Industrial Survey of Upper San Francisco Bay Area, with Special Reference to A Salt Water Barrier.

31—Santa Ana River Basin.
32—South Coastal Basin.

California State Library:

Vol. 25, No. 4.
Biennial Report of the California State Library, 1930.

California State Department of Public Works:

California Highways and Public Works:

January, 1931.
February, 1931.
March, 1931.

Seventh Biennial Report of the Division of Highways.

Connecticut State Geological and Natural History Survey:

Bulletin 47—The Glacial Geology of Connecticut. By R. F. Flint.

48—Additions to the Flora of Connecticut. (First Supplement to Bulletin No. 14.)

Florida State Geological Survey:

Bulletin 5—A Fossil Teleost Fish of the Snapper Family (Lutianidae) from the Lower Oligocene of Florida. By Wm. K. Gregory. The Foraminifera of the Marianna Limestone of Florida. By W. S. Cole and G. M. Ponton.

Kentucky Geological Survey:

Series VI, Vol 35—Geological Survey Affairs. By W. R. Jillson.
The Kentucky County. By W. R. Jillson.

Mississippi State Geological Survey:

Bulletin 23—Paleozoic Rocks. By W. C. Morse.

Nevada State Inspector of Mines:

Biennial Report, 1929–1930. By A. J. Stinson.

New Mexico State Bureau of Mines and Mineral Resources:

Bulletin 6—Mining and Mineral Laws of New Mexico. By C. H. Fowler.
Circular 2—Geology and Ore Deposits of the Ground Hog Mine, Central District, Grant County, New Mexico. By S. G. Lasky.
3—First, Second, and Third Annual Reports of the Director and Preliminary Report for the Fourth Year. By E. H. Wells.
4—The Hobbs Field and Other Oil and Gas Areas, Lea County, New Mexico. (Preliminary Report.) By D. E. Winchester.

Oklahoma Geological Survey:

Bulletins 52 and 53—Geology and Petrology of the Wichita Mountains. By M. G. Hoffman. Micropaleontology of the Wetumka, Wewoka, and Holdenville Formations. By A. S. Warthin, Jr.

Bulletin 54—The Stabilization of the Petroleum Industry. By L. M. Logan.

Pennsylvania Geological Survey:

Fourth Series—Administrative Report. By G. H. Ashley.
Bulletin M-13—Feldspar in Pennsylvania. By R. W. Stone and H. H. Hughes.

South Dakota Geological and Natural History Survey:

R. I. No. 8—The Cascade Anticline. By E. P. Rothrock.
R. I. No. 9—The Chilson Anticline. By E. P. Rothrock.

Virginia Geological Survey:

Bulletin No. 32—Sand and Gravel Resources of the Coastal Plains of Virginia. By C. K. Wentworth.

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Circular No. 5 and Supplement No. 1.

Canada Department of Mines:

Mines Branch:

No. 716—The Salt Industry of Canada. By L. H. Cole.

Geological Survey:

No. 2159—Prospecting in Canada.
No. 2218—Summary Report, 1928, Part C.
No. 2229—Zinc and Lead Deposits of Canada. By F. J. Alcock.
No. 2244—Geology of Southern Alberta and Southwestern Saskatchewan. By M. Y. Williams and W. S. Dyer.
No. 2250—Summary Report, 1929, Part C.
No. 2251—Summary Report, 1929, Part A.

Commission Geologique de Finlande:

No. 88, 92.

Secretaria de Industria, Comercio y Trabajo, Mexico:

Boletin del Petroleo:

Vol. XXIX, Num. 2, 3, 4, 5, 6.

Boletin Minero:

Tomo XXIX, Num. 5, 6.
Tomo XXX, Num. 1 y 2.

Department of Scientific and Industrial Research, Wellington, New Zealand:

63d Annual Report of the Dominion Laboratory.

Nova Scotia Department of Public Works and Mines:

Annual Report on the Mines, 1930.

Ontario Department of Mines:

Vol. XXXIX, Part IV, 1930—The Ceramic Industry of Ontario. By R. J. Montgomery.
Vol. XXXIX, Part I, 1930—39th Annual Report.
Bulletin 76—Preliminary Report on the Mineral Production of Ontario in 1930.

Geological—Prospecting Service of the East–Siberian Region of the U. S. S. R.:

No. 3—Records of the Geology and Mineral Resources of East–Siberia.
Fascicle 5, 7, 9, 13.

Geological and Prospecting Service of the U. S. S. R.:

XLIX, No. 7
Fascicle 14
Fascicle 16
Fascicle 1, 17, 19, 20, 23, 24, 27.

Scotland Department of Scientific and Industrial Research:

The Geology of Ardnamurchan, North–West Mull and Coll.
The Economic Geology of the Ayrshire Coalfields.

Societies and Educational Institutions.

Academy of Natural Sciences of Philadelphia:

Vol. LXXXII, 1930.

American Institute of Mining and Metallurgical Engineers:

Tech. Publ. No. 401—Experimental Flotation of Oxidized Silver Ores. By H. S. Gieser.
Tech. Publ. No. 410—Flotation of Minor Gold in Large-scale Copper Concentrators. By E. S. Leaver and J. A. Woolf.

Archivos do Museu Nacional, Rio De Janeiro:

Vol. XXXI, 1929.

American Petroleum Institute:

Vol. XI, No. 75—11th Annual Meeting Proceedings. Production.
Standardization Bulletin No. 105.

American Ceramic Society:

A Bibliography of Clays and the Ceramic Arts. By J. C. Branner, 1906.
Bibliography of Magnesite Refractories, 1924.
Bibliography of Silica Refractories, 1924.

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Vol. 10, Part 2.
Vol. 12, No. 5, Part 2.
Vol. 14, No. 2.

Australian Museum:

Vol. XVII, No. 9, 10.
Vol. XVIII, No. 1.

American Journal of Science:

Vol. XIX, Fifth Series, Nos. 109, 110, 111, 112, 113, 114.
Vol. XX, Fifth Series, Nos. 115, 116, 117, 118, 119, 120.
Vol. XXI, Fifth Series, Nos. 122, 123, 124.

American Philosophical Society:

Vol. LXIX, No. 8.

American Association of Petroleum Geologists:

Vol. 15, No. 1, January, 1931.
Vol. 15, No. 2, February, 1931
Vol. 15, No. 3, March, 1931.

Birmingham-Southern College:

Vol. 23, No. 5.

Carnegie Institution of Washington:

No. 393—Contributions to Paleontology—Papers concerning the Paleontology of the Cretaceous and Later Tertiary of Oregon, of the Pliocene of Northwestern Nevada, and of the Late Miocene and Pleistocene of California.

Colorado Scientific Society:

Vol. 12, No. 8.
Vol. 12, No. 9.
Vol. 12, No. 10.

Canadian Institute of Mining and Metallurgy:

No. 225, January, 1931.
No. 226, February, 1931.
No. 227, March, 1931.

Cleveland Museum of Natural History:

Vol. 1, No. 4.

Economic Geology:

Vol. XXVI, No. 1.
Vol. XXVI, No. 2.

Institution of Mining and Metallurgy:

Bulletin 316.
Bulletin 317.
Bulletin 318.
List of Members, Constitution and By-Laws and Royal Charter of Incorporation. January, 1931.

Institution of Petroleum Technologists, London:

Synthetic Lubricating Oils.
The Gaseous Products of Shale Retorting: Their Composition and Possible Utilization.

Institute of Economic Mineralogy, Moscow, Russia:
Nos. 229, 281, 299, 361, 363, 368, 371, 423.

Instituto Geologico de Mexico.
Tomo IV—Anales del Instituto de Geologia.

Journal of Geology:
Vol. XXXIX, No. 1.
Vol. XXXIX, No. 2.

Library of Congress:
Vol. 21, No. 10.
Vol. 21, No. 11.
Vol. 21, No. 12.

Metals and Alloys:
Vol. 2, No: 1, January, 1931.
Vol. 2, No. 2, February, 1931.

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Bulletin No. 215, Vol. 23, No. 8.
216, Vol. 24, No. 1.
217, Vol. 24, No. 2.

Mineralogical Society of America:
Vol. 16, No. 1.
16, No. 2.
16, No. 3.

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Technical Series, Vol. 11, No. 3.

National Research Council of Canada:
Vol. 3, No. 6, December, 1930.

Northwest Science:
Vol. IV, No. 4.

Pennsylvania State College:
Bulletin No. 39. Oil Film Pressures in a Complete Bearing. By L. J. Bradford and L. J. Grunder.
Bulletin 8. Oil–Field Waters of Pennsylvania. By C. F. Barb.

Philippine Journal of Science:
Vol. 44, Nos. 1–2.
Vol. 44, No. 3.

Real Academia de Ciencios y Artes:
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Tercera Epoca, Vol. XXII, Num. 8, 9, 10, y 11.

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Leidsche Geologische Mededeelingen. Deel III.

Special Libraries Association of San Francisco:
Preliminary Union List of Periodicals in the Libraries of the San Francisco Bay Region. February, 1931.

The Commonwealth Club, San Francisco:
Vol. VII, No. 3, Part II.
Vol. VII, No. 9, Part II.
Vol. VII, No. 14.

University of California (Publications in Geography):
Vol. 1, No. 7. Preliminary Report on the Recent Volcanic Activity of Lassen Peak. By R. S. Holway.
No. 8. Physiographic Features of Cache Creek in Yolo County. By D. M. Durst.

No. 9. Report of the Meteorological Station at Berkeley, California, for the Year Ending June 30, 1914. By W. G. Reed.
No. 10. Report of the Meteorological Station at Berkeley, California, for the Year Ending June 30, 1915. By W. G. Reed.
Vol. 2, No. 1. Thirty-Year Synopsis. Meteorological Observations Made at Berkeley from July 1, 1887 to June 30, 1917. By B. M. Varney.
No. 3. Graphic Studies in Climatology. By J. B. Leighly.
No. 5. The East Bolivian Andes South of the Rio Grande or Guapay. By O. Schmieder.
No. 6. The Cylindrical Equal-Area Projection. By C. W. Thornthwaite.
No. 7. Landslide Lakes of the Northwestern Great Basin. By R. J. Russell.
No. 8. The Pampa—A Natural or Culturally Induced Grass-Land? By O. Schmieder.
No. 9. Lower California Studies. I-Site and Culture at San Fernando de Velicata. By C. Sauer and P. Meigs.
No. 10. Alteration of the Argentine Pampa in the Colonial Period. By O. Schmieder.
No. 11. The Land Forms of Surprise Valley, Northwestern Great Basin. By R. J. Russell.
No. 12. The Historic Geography Tucuman. By O. Schmieder.
No. 13. Graphic Studies in Climatology II. The Polar Form of Diagram in the Plotting of the Annual Climatic Cycle. By J. B. Leighly.
No. 14. Lower California Studies II. The Russian Colony of Guadalupe Valley. By O. Schmieder.
Vol. 3, No. 1. The Towns of Malardalen in Sweden. A Study in Urban Morphology. By J. B. Leighly.
No. 2. Glacial Land Forms in the Sierra Nevada South of Lake Tahoe. By W. D. Jones.
No. 3. The Brazilian Culture Hearth. By O. Schmieder.
No. 4. Land Forms in the Peninsular Range of California as Developed About Warner's Hot Springs and Mesa Grande. By C. Sauer.
No. 5. Summer Sea Fogs of the Central California Coast. By H. R. Byers.
No. 6. Basin and Range Forms in the Chiricahua Area. By C. Sauer.
No. 7. Pueblo Sites in Southeastern Arizona. By C. Sauer and D. Band.
Vol. 4. The Settlements of the Tzapotec and Mije Indians, Oaxaca, Mexico. By O. Schmieder.
Vol. 5, No. 1. Dry Climates of the U. S. I. Climatic Map. By R. J. Russell.

Bulletin of the Department of Geological Sciences:

Vol. 19, No. 18. The Gastropod Genus Galeodea in the Oligocene of Washington. By N. M. Tegland.
No. 19. Cephalopods of the Genus Aturia from Western North America. By H. G. Schenck.
Vol. 20, No. 1. Critical Observations on the Phylogeny of the Rhinoceroses. By W. D. Matthew.
No. 2. A Vertebrate Fauna from a New Pliocene Formation in Northern California. By R. D. Russell and V. L. Vander Hoof.

United Engineering Trustees, Inc.:

Reports for Years 1929–1930.

Western Society of Engineers:

Vol. XXXVI, No. 1.

Books.

Oil Well Cementing. By Owen Oil Well Cementing Co., Inc.
Pit and Quarry Handbook and Directory, 1931. 24th Edition.

John Hays Hammond Public Mining Library.

Secondary Aluminum. By R. J. Anderson.

Maps.

Republica Argentina:

Mapa Hipsometrico de la Republica Argentina y Regiones Limitropes. 1930.

U. S. Geological Survey Topographic Sheets:

Arizona:

Aguila Mountains Quadrangle, Yuma County.
Linskey Quadrangle, Yuma County.
Stoval Quadrangle, Yuma County.

California:

Avawatz Mountains Quadrangle, Los Angeles County.
Chatsworth Quadrangle, Los Angeles County.
Compton Quadrangle, Los Angeles County.
Dry Canyon Quadrangle; Los Angeles County.
Hamlin School Quadrangle, Kern County.
Leonards Quadrangle, Kern County.
Los Flores Quadrangle, Los Angeles County.
McFarland Quadrangle, Kern County.
Miramonte Quadrangle, Kern County.
Naval Petroleum Reserve No. 1, Kern County.
Pond Quadrangle, Kern County.
Sylmar Quadrangle, Los Angeles County.
Wasco Quadrangle, Kern County.
Zelzah Quadrangle, Los Angeles County.

Colorado:

Glenwood Springs Quadrangle.

Iowa:

Mitchellville Quadrangle.

Missouri:

Coldwater Quadrangle.

New Mexico:

Tucumcari Quadrangle.

North Dakota:

Drake Quadrangle.
Hamar Quadrangle.

Oklahoma:

McLond Quadrangle.

Oregon:

Mt. Jefferson Quadrangle.

Texas:

Bassett Quadrangle.
Belton Quadrangle.
Ivan Quadrangle.
Killeen Quadrangle.
Lockhart Quadrangle.
Richland Springs Quadrangle.
Seguin Quadrangle.
Tilden Quadrangle.
Whitsett Quadrangle.

Washington:

Chewelah Quadrangle.

Current Magazines on File.

For the convenience of persons wishing to consult the technical magazines in the reading room, a list of those on file is appended:

Architect and Engineer, San Francisco.
Asbestos, Philadelphia, Pennsylvania.
Asbestology, Canadian Asbestos Co., Montreal, Canada.
Brick and Clay Record, Chicago.
California Safety News, San Francisco.
Canadian Mining Journal, Gardenvale, Quebec.
Caterpillar, San Leandro, California.
Chemical Engineering and Mining Review, Melbourne, Australia.
Chemical & Metallurgical Engineering, New York City.
Commerce Reports, Washington, D. C.
Colorado School of Mines, Golden, Colorado.
Cooper–Bessemer Monthly, Grove City, Pennsylvania.
Engineering and Mining Journal, New York City.
Explosive Service Bulletins, Washington, Delaware.
Fuel Oil, Chicago, Illinois.
Fusion Facts, Whittier, California.
Graphite, Jersey City.
Grizzly Bear, Los Angeles.
Hercules Mixer, Wilmington, Delaware.
Industrial Employment Information Bulletin, Washington, D. C.
Lubrication, The Texas Co., New York City.
Mining Congress Journal, Washington, D. C.
Mining and Industrial Record, Vancouver, B. C.
Mining Journal, Phoenix, Arizona.
Mining Journal, London.
Mining and Metallurgy, New York City.
Mining Review, Salt Lake City.
Mining Truth, Spokane, Washington.
Monthly Review of Business Conditions, San Francisco.
National Sand and Gravel, Washington, D. C.
Oil Bulletin, Los Angeles.
Oil and Gas Journal, Tulsa, Oklahoma.
Oil, Paint and Drug Reporter, New York City.
Oil Weekly, Houston, Texas.
Pacific Purchaser, San Francisco.
Petroleum Age, Chicago.
Petroleum Times, London, E. C. 2.
Petroleum World, Los Angeles.
Pit and Quarry, Chicago.
Queensland Government Mining Journal, Brisbane, Australia.
Record, Associated Oil Co., San Francisco.
Rock Products, Chicago.
Rocks and Minerals, Peekskill, New York.
Scientific American, New York City.
Southwest Builder and Contractor, Los Angeles.
Standard Oil Bulletin, San Francisco.
Stone, New York City.
Through the Ages, Baltimore.

Newspapers.

The following papers are received and kept on file in the library:

Amador Dispatch, Jackson, California.
Barstow Printer, Barstow, California.
Beaumont Gazette, Beaumont, California.
Bridgeport Chronicle–Union, Bridgeport, California.
Calaveras Californian, Angels Camp, California.
Calaveras Prospect, San Andreas, California.
California Oil World, Los Angeles, California.
Colusa Daily Sun, Colusa, California.

Daily Commercial News, San Francisco, California.
Daily Midway Driller, Taft, California.
Del Norte Triplicate, Crescent City, California.
Denver Mining Record, Denver, Colorado.
Exeter Sun, Exeter, California.
Goldfield News, Goldfield, Nevada.
Inyo Independent, Independence, California.
Inyo Register, Bishop, California.
Ione Valley Echo, Ione, California.
Las Vegas Age, Las Vegas, Nevada.
Livermore Herald, Livermore, California.
Mariposa Gazette, Mariposa, California.
Mercury Register, Oroville, California.
Mojave Miner, Kingman, Arizona.
Mojave-Randsburg Record, Mojave, California.
Morning Union, Grass Valley, California.
Mountain Messenger, Downieville, California.
National Industrial Review, San Francisco, California.
Needles Nugget, Needles, California.
Nevada City Nugget, Nevada City, California.
Nevada Mining Press, Reno, Nevada.
Oil Refinery News, Bayonne, New Jersey.
Petroleum Press, Taft, California.
Placer Herald, Auburn, California.
Plumas Independent, Quincy, California.
San Diego News, San Diego, California.
Shasta Courier, Redding, California.
Siskiyou News, Yreka, California.
Sotoyome Scimitar, Healdsburg, California.
Stockton Record, Stockton, California.
Tehachapi News, Tehachapi, California.
Tuolumne Prospector, Tuolumne, California.
Ventura County News, Ventura, California.
Waterford News, Waterford, California.
Weekly Trinity Journal, Weaverville, California.
Western Sentinel, Etna Mills, California.
Western Mineral Survey, Salt Lake City, Utah.

PRODUCERS AND CONSUMERS

The producer and consumer of mineral products are mutually dependent upon each other for their prosperity, and one of the most direct aids rendered by the Bureau to the mining industry in the past has been that of bringing producers and consumers into direct touch with each other.

This work has been carried on largely by correspondence, supplemented by personal consultation. Lists of buyers of all the commercial minerals produced in California have been made available to producers upon request, and likewise the owners of undeveloped deposits of various minerals, and producers of them, have been made known to those looking for raw mineral products.

When the publication of MINING IN CALIFORNIA was on a monthly basis, current inquiries from buyers and sellers were summarized and lists of mineral products or deposits 'wanted' or 'for sale' included in each issue.

It is important that inquiries of this nature reach the mining public as soon as possible and in order to avoid the delay incident to the present quarterly publication of MINING IN CALIFORNIA, these lists are now issued monthly in the form of a mimeographed sheet under the title of 'Commercial Mineral Notes,' and sent to those on the mailing list for MINING IN CALIFORNIA.

EMPLOYMENT SERVICE

Following the establishment of the Mining Division branch offices in 1919, a free technical employment service was offered as a mutual aid to mine operators and technical men for the general benefit of the mineral industry.

Briefly summarized, men desiring positions are registered, the cards containing an outline of the applicant's qualifications, position wanted, salary desired, etc., and as notices of 'positions open' are received, the names and addresses of all applicants deemed qualified are sent to the prospective employer for direct negotiations.

Telephone and telegraphic communications are also given immediate attention.

Technical men, or those qualified for supervisory positions, and vacancies of like nature only, are registered, as no attempt will be made to supply common mine and mill labor.

Registration cards for the use of both prospective employers and employees may be obtained upon request, and a cordial invitation is extended to the industry to make free use of the facilities afforded. Parties interested should communicate direct with our San Francisco office.

PUBLICATIONS OF THE DIVISION OF MINES

During the past fifty-one years, in carrying out the provisions of the organic act creating the former California State Mining Bureau, there have been published many reports, bulletins and maps which go to make up a library of detailed information on the mineral industry of the State, a large part of which could not be duplicated from any other source.

One feature that has added to the popularity of the publications is that many of them have been distributed without cost to the public, and even the more elaborate ones have been sold at a price which barely covers the cost of printing.

Owing to the fact that funds for the advancing of the work of this department have often been limited, many of the reports and bulletins mentioned were printed in limited editions which are now entirely exhausted.

Copies of such publications are available, however, in the office of the Division of Mines, in the Ferry Building, San Francisco; Bankers Building, Los Angeles; State Office Building, Sacramento; Redding; Santa Maria; Santa Paula; Coalinga; Taft; Bakersfield. They may also be found in many public, private and technical libraries in California and other states, and foreign countries.

A catalog of all publications from 1880 to 1917, giving a synopsis of their contents, is issued as Bulletin No. 77.

Publications in stock may be obtained by addressing any of the above offices and enclosing the requisite amount in the case of publications that have a list price. Only coin, stamps or money orders should be sent, and it will be appreciated if remittance is made in this manner rather than by personal check.

The prices noted include delivery charges to all parts of the United States. Money orders should be made payable to the Division of Mines.

NOTE.—The Division of Mines frequently receives requests for some of the early Reports and Bulletins now out of print, and it will be appreciated if parties having such publications and wishing to dispose of them will advise this office.

REPORTS

Asterisks (**) indicate the publication is out of print.

	Price
**First Annual Report of the State Mineralogist, 1880, 43 pp. Henry G. Hanks	----
**Second Annual Report of the State Mineralogist, 1882, 514 pp., 4 illustrations, 1 map. Henry G. Hanks	----
**Third Annual Report of the State Mineralogist, 1883, 111 pp., 21 illustrations. Henry G. Hanks	----
**Fourth Annual Report of the State Mineralogist, 1884, 410 pp., 7 illustrations. Henry G. Hanks	----
**Fifth Annual Report of the State Mineralogist, 1885, 234 pp., 15 illustrations, 1 geological map. Henry G. Hanks	----
**Sixth Annual Report of the State Mineralogist, Part I, 1886, 145 pp., 3 illustrations, 1 map. Henry G. Hanks	----
**Part II, 1887, 222 pp., 36 illustrations. William Irelan, Jr.	----
**Seventh Annual Report of the State Mineralogist, 1887, 315 pp. William Irelan, Jr.	----
**Eighth Annual Report of the State Mineralogist, 1888, 948 pp., 122 illustrations. William Irelan, Jr.	----
**Ninth Annual Report of the State Mineralogist, 1889, 352 pp., 57 illustrations, 2 maps. William Irelan, Jr.	----

REPORTS—Continued

Asterisks (**) indicate the publication is out of print.

	Price
**Tenth Annual Report of the State Mineralogist, 1890, 983 pp., 179 illustrations, 10 maps. William Irelan, Jr.	----
Eleventh Report (First Biennial) of the State Mineralogist, for the two years ending September 15, 1892, 612 pp., 73 illustrations, 4 maps. William Irelan, Jr.	$1.00
**Twelfth Report (Second Biennial) of the State Mineralogist, for the two years ending September 15, 1894, 541 pp., 101 illustrations, 5 maps. J. J. Crawford	----
**Thirteenth Report (Third Biennial) of the State Mineralogist, for the two years ending September 15, 1896, 726 pp., 93 illustrations, 1 map. J. J. Crawford	----
Chapters of the State Mineralogist's Report, Biennial Period, 1913–1914, Fletcher Hamilton:	
**Mines and Mineral Resources, Amador, Calaveras and Tuolumne Counties, 172 pp., paper	----
Mines and Mineral Resources, Colusa, Glenn, Lake, Marin, Napa, Solano, Sonoma and Yolo Counties, 208 pp., paper	.50
**Mines and Mineral Resources, Del Norte, Humboldt and Mendocino Counties, 59 pp., paper	----
**Mines and Mineral Resources, Fresno, Kern, Kings, Madera, Mariposa, Merced, San Joaquin and Stanislaus Counties, 220 pages, paper	----
**Mines and Mineral Resources of Imperial and San Diego Counties, 113 pp., paper	----
**Mines and Mineral Resources, Shasta, Siskiyou and Trinity Counties, 180 pp., paper	----
**Fourteenth Report of the State Mineralogist, for the Biennial Period 1913–1914, Fletcher Hamilton, 1915:	
A General Report on the Mines and Mineral Resources of Amador, Calaveras, Tuolumne, Colusa, Glenn, Lake, Marin, Napa, Solano, Sonoma, Yolo, Del Norte, Humboldt, Mendocino, Fresno, Kern, Kings, Madera, Mariposa, Merced, San Joaquin, Stanislaus, San Diego, Imperial, Shasta, Siskiyou and Trinity Counties, 974 pp., 275 illustrations, cloth	----
Chapters of the State Mineralogist's Report, Biennial Period, 1915–1916. Fletcher Hamilton:	
**Mines and Mineral Resources, Alpine, Inyo and Mono Counties, 176 pp., paper	----
Mines and Mineral Resources, Butte, Lassen, Modoc, Sutter and Tehama Counties, 91 pp., paper	.50
Mines and Mineral Resources, El Dorado, Placer, Sacramento and Yuba Counties, 198 pp., paper	.65
Mines and Mineral Resources, Monterey, San Benito, San Luis Obispo, Santa Barbara and Ventura Counties, 183 pp., paper	.65
**Mines and Mineral Resources, Los Angeles, Orange and Riverside Counties, 136 pp., paper	----
**Mines and Mineral Resources, San Bernardino and Tulare Counties, 186 pp., paper	----
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**Map of Madera County, Showing Boundaries, National Forests	----
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**Map of Shasta County, Showing Boundaries, National Forests	----
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Map No. 42—Playa Del Rey, Los Angeles County	.75

DETERMINATION OF MINERAL SAMPLES

Samples (limited to three at one time) of any mineral found in the State may be sent to the Division of Mines for identification, and the same will be classified free of charge. No samples will be determined if received from points outside the State. It must be understood that no assays, or quantitative determinations will be made. Samples should be in lump form if possible, and marked plainly with name of sender on outside of package, etc. No samples will be received unless delivery charges are prepaid. A letter should accompany sample, giving locality where mineral was found and the nature of the information desired.

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STATE OF CALIFORNIA
DEPARTMENT OF NATURAL RESOURCES

DIVISION OF MINES

CORDIALLY INVITES YOU TO VISIT ITS VARIOUS DEPARTMENTS MAINTAINED FOR THE PURPOSE OF FURTHERING THE DEVELOPMENT OF THE

MINERAL RESOURCES OF CALIFORNIA

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WALTER W. BRADLEY,
State Mineralogist.

Third floor, Ferry Building, San Francisco, Cal. Branch Offices: Bankers Building, Los Angeles; State Office Building, Sacramento; Chamber of Commerce, Redding; Bank of Italy Building, Bakersfield; San Marcos Building, Santa Barbara; Taft, Coalinga and Santa Paula.

Mining in California

PUBLISHED QUARTERLY

STATE OF CALIFORNIA
DEPARTMENT OF NATURAL RESOURCES
DIVISION OF MINES

FERRY BUILDING
SAN FRANCISCO

DIVISION OF MINES

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STATE OF CALIFORNIA
DEPARTMENT OF NATURAL RESOURCES
DIVISION OF MINES
FERRY BUILDING, SAN FRANCISCO

WALTER W. BRADLEY — State Mineralogist

Vol. 27 — JULY, 1931 — No. 3

CHAPTER OF

REPORT XXVII OF THE STATE MINERALOGIST

COVERING

ACTIVITIES OF THE DIVISION OF MINES

INCLUDING THE

GEOLOGIC BRANCH

CALIFORNIA STATE PRINTING OFFICE
HARRY HAMMOND, STATE PRINTER
SACRAMENTO, 1931

TABLE OF CONTENTS

	Page
DISTRICT REPORTS OF MINING ENGINEERS	245
Redding Field Division	245
Sacramento Field Division	246
Yuba County	246
San Francisco Field Division	261
Los Angeles Field Division	262
San Bernardino County	262
GEOLOGIC BRANCH	402
OIL FIELD DEVELOPMENT OPERATIONS	404
SPECIAL ARTICLES	407
Feldspar, Silica, Andalusite and Cyanite Deposits of California	407
A Note on a Deposit of Andalusite in Mono County, California: Its Occurrence and Technical Importance	459
Establishment of Trinity and Klamath River Fish and Game District Affects Mining	465
U. S. Mint Aids Prospectors	466
ADMINISTRATION	467
DIVISION OF MINERALS AND STATISTICS	468
Statistics	468
Museum	470
Laboratory	471
LIBRARY	472
PRODUCERS AND CONSUMERS	485
EMPLOYMENT SERVICE	486
PUBLICATIONS	I

PREFACE

The Division of Mines (formerly State Mining Bureau) is maintained for the purpose of assisting in all possible ways in the development of California's mineral resources.

As one means of offering tangible service to the mining public, the State Mineralogist for many years has issued an annual or a biennial report reviewing in detail the mines and mineral deposits of the various counties.

As a progressive step in advancing the interests of the mineral industry, and as permitting earlier distribution to the public, publication of the Annual Report of the State Mineralogist in the form of monthly chapters was begun in January, 1922, and continued until March, 1923.

Owing to a lack of funds for printing this was changed to a quarterly publication, beginning in September, 1923.

For the same reason, beginning with the January, 1924, issue, it has been necessary to charge a subscription price of $1 per calendar year, payable in advance; single copies, 25 cents apiece. 'Mining in California' is sent without charge to our 'exchange list,' including schools and public libraries, as are also other publications of the Division of Mines.

Pages are numbered consecutively throughout the year and an index to the complete report is included annually in the closing number.

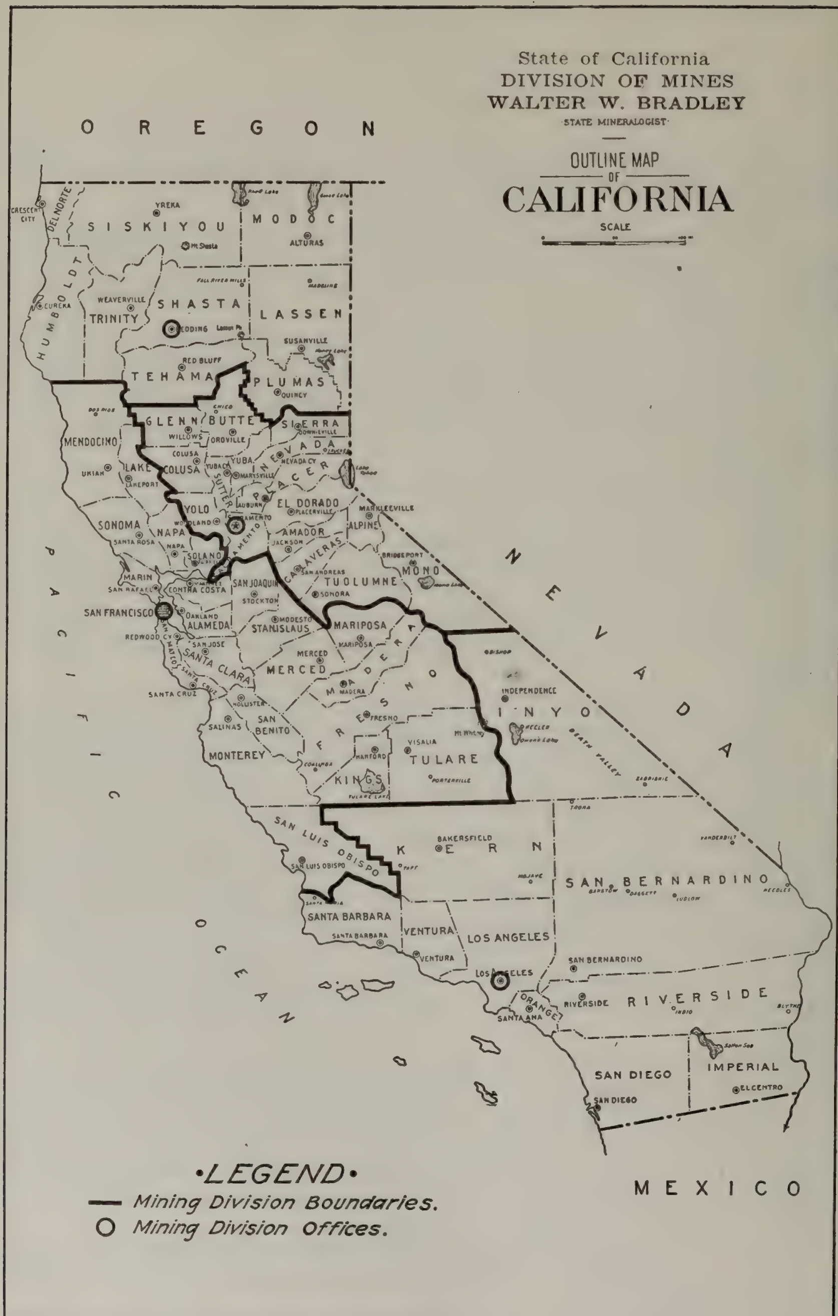
Such a publication admits of several improvements over the former method of procedure. Each issue contains a report of the current development and mining activities of the State, prepared by the district mining engineers. Special articles dealing with various phases of mining and allied subjects by members of the staff and other contributors are included. Mineral production reports formerly issued only as an annual statistical bulletin are published herein as soon as returns from producers are compiled. The executive activities, and those of the laboratory, museum, library, employment service and other features with which the public has had too little acquaintance also are reported.

Beginning with the 1930 issues, the activities and progress of the Geologic Branch are recorded also in these quarterly chapters.

While current activities of all descriptions are covered in these chapters, the practice of issuing from time to time technical reports on special subjects will be continued, as well. A list of such reports now available is appended hereto, and the names of new bulletins will be added in the future as they are completed.

The chapters are subject to revision, correction and improvement. Constructive suggestions from the mining public will be gladly received, and are invited.

The one aim of the Division of Mines is to increase its usefulness and to stimulate the intelligent development of the wonderful, latent resources of the State of California.


State of California
DIVISION OF MINES
WALTER W. BRADLEY
STATE MINERALOGIST
OUTLINE MAP OF CALIFORNIA
SCALE
OREGON
NEVADA
MEXICO
PACIFIC OCEAN
SISKIYOU
MODOC
DEL NORTE
HUMBOLDT
TRINITY
SHASTA
LASSEN
TEHAMA
PLUMAS
GLENN
BUTTE
SIERRA
MENDOCINO
LAKE
COLUSA
YUBA
NEVADA
SUTTER
PLACER
YOLO
EL DORADO
SONOMA
NAPA
SOLANO
SACRAMENTO
AMADOR
ALPINE
MARIN
CONTRA COSTA
SAN JOAQUIN
CALAVERAS
TUOLUMNE
MONO
SAN FRANCISCO
ALAMEDA
STANISLAUS
MARIPOSA
SAN MATEO
SANTA CLARA
MERCED
MADERA
SANTA CRUZ
SAN BENITO
FRESNO
INYO
MONTEREY
KINGS
TULARE
SAN LUIS OBISPO
KERN
SAN BERNARDINO
SANTA BARBARA
VENTURA
LOS ANGELES
ORANGE
RIVERSIDE
SAN DIEGO
IMPERIAL
CRESCENT CITY
YREKA
ALTURAS
EUREKA
WEAVERVILLE
REDDING
SUSANVILLE
RED BLUFF
QUINCY
WILLOWS
OROVILLE
DOWNIEVILLE
UKIAH
LAKEPORT
YUBA CITY
MARYSVILLE
NEVADA CITY
AUBURN
PLACERVILLE
MARKLEEVILLE
WOODLAND
SANTA ROSA
JACKSON
BRIDGEPORT
SAN ANDREAS
SAN RAFAEL
SONORA
STOCKTON
OAKLAND
MODESTO
REDWOOD CITY
SAN JOSE
MARIPOSA
MERCED
INDEPENDENCE
SANTA CRUZ
HOLLISTER
MADERA
FRESNO
SALINAS
VISALIA
HANFORD
PORTERVILLE
BAKERSFIELD
SAN LUIS OBISPO
SANTA BARBARA
VENTURA
SAN BERNARDINO
LOS ANGELES
RIVERSIDE
SANTA ANA
SAN DIEGO
EL CENTRO
•LEGEND•
Mining Division Boundaries.
Mining Division Offices.

DISTRICT REPORTS OF MINING ENGINEERS

In 1919–1920 the Mining Bureau was organized into four main geographical divisions, with the field work delegated to a mining engineer in each district, working out from field offices that were established in Redding, Auburn, San Francisco and Los Angeles, respectively. This move brought the office into closer personal contact with operators, and it has many advantages over former methods of conducting field work. In 1923 the Redding and Auburn field offices were consolidated and moved to Sacramento.

The Redding office was reestablished in 1928, and the boundaries of each district adjusted. The counties now included in each of the four divisions, and the locations of the branch offices, are shown on the accompanying outline map of the State. (Frontispiece.)

Reports of mining activities and development in each division, prepared by the district engineer, will continue to appear under the proper field division heading.

Although the petroleum industry is but little affiliated with other branches of mining, oil and gas are among the most valuable mineral products of California, and a report by the State Oil and Gas Supervisor on the current development and general conditions in the State's oil fields is included under this heading.

New County Reports.

The series of separate reports on the mines and mineral resources of the different counties, that together comprise the State Mineralogist's Reports XVI to XVII, inclusive, in the case of many of the counties have become exhausted. Those still in stock being in need of revision, it was deemed advisable, beginning with the January, 1925, issue of 'Mining in California,' to make the district engineers' reports in the form of a complete general report on the mines and mineral resources in one or more of the counties in each district.

This program has been followed as nearly as possible in succeeding numbers of the quarterly, and the county series completed during 1930. A new series of reports on individual economic minerals, mainly nonmetallics, is now (1931) under way.

REDDING FIELD DIVISION

CHAS. VOLNEY AVERILL, Mining Engineer

There is no report from the Redding Field Division, as the present series of county reports is complete for that district, and Mr. Chas. V. Averill, District Mining Engineer, is engaged on geological field studies in the Shasta Quadrangle.

SACRAMENTO FIELD DIVISION

C. A. Logan, Mining Engineer

YUBA COUNTY

Geography.

Of irregular shape, having a length of 45 miles from northeast to southwest and an area of 639 square miles, Yuba County extends from the Sacramento Valley to an elevation of 3500 feet, sharing the physical and geologic characteristics of the neighboring counties of Butte, Placer and Nevada. Marysville, the county seat, is 50 miles by paved highway from Sacramento, and the valley portion of the county is served by three railroads. The westerly third of the county is flat valley land, breaking into rolling foothills near Browns Valley, these in turn passing into the lower mountain slopes. Yuba River and Honcut Creek, flowing southwest into Feather River, drain the county. Good timber is found in abundance above the 2000-ft. contour. Farming, and particularly fruit-raising, is the principal industry in the valley and the summer ranging of cattle and the cutting of some lumber are the principal activities of the mountain section. A number of small hamlets are scattered along the roads extending from Marysville and Oroville, which join at Challenge, thence climbing the mountains to La Porte and Quincy in Plumas County. The few mining districts are served by good dirt roads.

Although electric power is generated on a large scale at Bullards Bar, it is not generally available to the scattered small mines. The quartz prospects usually develop enough water from their own workings for milling.

Mineral Resources and Geology.

Because of the rich dredging field surrounding Hammonton and Marigold on Yuba River 12 miles east of Marysville, Yuba County has long been one of the leading gold-producing counties of the state. Sand dredged from Yuba River is next in importance. Silver, which occurs alloyed with gold (but is not mined separately), and metals of the platinum group, which are a by-product of gold dredging, are next in value. In years past there has been small and irregular production of brick, pottery clay, mineral water, copper and natural gas. None of these is being worked now. Asbestos and soapstone prospects occur, but have appeared either too small or too remote to merit development.

The valley portion of the county to within a mile of the town of Browns Valley, is covered by sand and gravel, with a mantle of fertile soil in the region contiguous to the rivers. The dredging fields lie on the Yuba River and its adjacent flood plain for several miles in length, beginning where the stream breaks from its rocky canyon near Parks Bar bridge, spreading over the 'false bedrock' of volcanic ash which lies under the gravel and which forms the bottom for dredging work.

The foothill region beginning near Browns Valley is entirely of greenstones classified as diabase, porphyrite and 'amphibolite schist' from 9 to 11 miles northeastward, and such rocks evidently mantled the

MINERAL PRODUCTION OF YUBA COUNTY, 1880-1930

Year	Gold, value	Silver, value	Platinum		Miscellaneous stone,[1] value	Miscellaneous and unapportioned		
			Ounces	Value		Amount	Value	Substance
1880	$943,860	$438	-----	-----	-----	-----	-----	
1881	800,000	1,300	-----	-----	-----	-----	-----	
1882	750,000	-----	-----	-----	-----	-----	-----	
1883	455,000	-----	-----	-----	-----	-----	-----	
1884	250,000	-----	-----	-----	-----	-----	-----	
1885	207,449	-----	-----	-----	-----	-----	-----	
1886	149,203	-----	-----	-----	-----	-----	-----	
1887	162,426	-----	-----	-----	-----	-----	-----	
1888	150,000	-----	-----	-----	-----	-----	-----	
1889	112,053	115	-----	-----	-----	-----	-----	
1890	141,781	-----	-----	-----	-----	-----	-----	
1891	37,576	-----	-----	-----	-----	-----	-----	
1892	44,218	-----	-----	-----	-----	-----	-----	
1893	30,839	-----	-----	-----	-----	-----	-----	
1894	107,480	-----	-----	-----	-----	-----	-----	
1895	111,482	-----	-----	-----	-----	-----	-----	
1896	171,688	-----	-----	-----	-----	-----	-----	
1897	141,638	-----	-----	-----	-----	-----	-----	
1898	166,865	-----	-----	-----	-----	-----	-----	
1899	189,927	12	-----	-----	-----	-----	-----	
1900	280,366	[2]2,041	-----	-----	-----	-----	-----	
1901	188,908	[2]393	-----	-----	-----	-----	-----	
1902	155,630	2	-----	-----	-----	-----	-----	
1903	125,830	41	-----	-----	-----	-----	-----	
1904	139,528	-----	-----	-----	-----	400 M. 375 tons	$3,000 750	Brick. Pottery clay.
1905	324,135	369	-----	-----	-----	400 tons 2,000 gals.	80 800	Pottery clay. Mineral water.
1906	[3]	[3]	-----	-----	-----	2,000 gals.	800	Mineral water.
1907	1,766,770	6,167	-----	-----	-----	1,800 gals.	720	Mineral water.
1908	2,034,486	9,997	-----	-----	$5,750	1,000 M.	10,000	Brick.
1909	2,469,865	4,156	-----	-----	5,650	550 M. -----	6,600 568,564	Brick. Unapportioned, 1900-1909.
1910	3,204,273	5,372	-----	-----	-----	-----	-----	
1911	2,997,072	5,299	-----	-----	9,318	-----	-----	
1912	2,753,408	6,198	-----	-----	15,526	-----	-----	
1913	2,491,505	7,571	-----	-----	8,063	-----	-----	
1914	2,800,713	5,295	74	$2,377	14,895	-----	-----	
1915	2,703,710	5,254	132	4,174	149,292	-----	-----	
1916	3,167,723	5,934	314	14,301	42,685	4,817 lbs. -----	1,185 6,000	Copper. Other minerals.
1917	3,667,673	6,591	149	8,869	28,863	-----	-----	
1918	3,767,933	13,796	189	12,930	43,338	-----	6,888	Other minerals.
1919	4,195,732	12,276	[4]125	13,098	40,439	-----	-----	
1920	3,467,769	16,502	113	14,395	74,943	-----	40	Other minerals.
1921	4,738,248	26,135	179	14,396	73,387	-----	100	Other minerals.
1922	2,492,948	8,222	115	11,077	75,969	-----	100	Other minerals.
1923	3,150,405	6,760	158	16,974	216,890	-----	100	Other minerals.
1924	1,995,434	4,461	73	8,773	181,113	-----	100	Othre minerals.
1925	2,570,630	6,400	[3]	-----	137,288	-----	7,276	Natural gas, platinum.
1926	2,769,703	6,398	[3]	-----	133,298	-----	11,695	Natural gas, platinum.
1927	3,468,201	6,743	-----	-----	198,688	-----	6,000	Other minerals.
1928	2,304,377	4,910	[3]	-----	202,708	-----	17,081	Other minerals.
1929	1,456,039	2,648	[3]	-----	364,326	-----	7,358	Other minerals.
1930	968,814	1,255	-----	-----	[3]	-----	48,330	
Totals	$73,741,313	$189,051	1,621	$121,364	$2,022,429	-----	$703,567	

[1] Includes crushed rock, sand, gravel.
[2] Recalculated to 'commercial' from 'coining value' as originally published.
[3] See under 'Unapportioned.'
[4] Includes some palladium.

region once nearly to the easterly county line. Erosion of the higher hills has, however, revealed the upper surfaces of the granitic batholiths composed of gabbrodiorite and granodiorite, which originally intruded the overlying greenstones and cooled and crystallized under a great depth of these rocks, which have since been carried away. East of the greenstones and granitic rocks, in the northeastern corner of the county, there is a small area of the Calaveras (Carboniferous) rocks, principally hard slaty schist and quartzite with accompanying serpentine, succeeded on the east by amphibolite.

The most important quartz mines have been in the Browns Valley district, where an area of 'amphibolite schist' striking northwest indicates that the rock has been subject to great pressure and to chemical action. The Too Handy vein, now being prospected, is in this 'amphibolite schist,' which here shows several distinctly different bands of rock, including a coarsely crystaline gabbro or diabase; a grey felsitic rock with flow structure and a black, schistose graphitic dike, probably of Calaveras rocks, caught up in the original diabase intrusive. An intrusive body of granodiorite has also been encountered here, about five miles from the nearest mapped outcrop. This area of amphibolite schist extends across the county to the southeast, but although other veins occur in it, none have so far proved valuable.

The veins at Dobbins are in gabbrodiorite. Those near Challenge are in 'amphibolite schist' and those near Hansonville lie in or near the contact of gabbrodiorite and diabase.

The Neocene Yuba River entered the county a mile east of Smartsville. From the section about 2½ miles long which had escaped erosion much gold was taken by hydraulicking. The eroded sections contributed to the richness of the dredging fields.

GOLD (QUARTZ MINES)

Gold quartz mining in Yuba County has been almost at a standstill during the past ten years. There is little to add to the reports previously published. Some work is being done near Browns Valley at the Too Handy Mine, near Dobbins at the Red Cross and near Challenge at the Mount de Oro, Beehive and other properties. The quartz prospects occur in the amphibolite and in the vicinity of the contacts of basic igneous intrusives of granitic texture with the amphibolite schists and similar greenstones. Quartz mining has never been of much importance in this county though there have been numerous surface showings which have yielded pockets and small tonnages of good ore. The various prospects and old mines were described in a chapter of the State Mineralogist's Fifteenth Report, which is still available for sale. The notes herewith cover only the work since that report was written.

The total recorded production of gold quartz ore in the county from 1914 to 1928, inclusive, was only 2500 tons which yielded less than $27,000. Besides those mentioned in detail, some ore and tailing was worked by the cyanide process at the *Henry George Mine* in 1925, and some work was done at the *Good Title Mine* in 1924. The *California Mother Lode Mine* in the same district was a producer in 1913, but has been idle and the subject of litigation since.

Beehive or *Mount Hope Mine* is two miles from Woodleaf on the Oroville-La Porte road in Sec. 8, T. 19 N., R. 7 E. *Mount Hope Mining Company,* Thomas Snook, secretary and manager, Woodleaf, is engaged in reopening it. There are two claims and a millsite.

An old inclined shaft sunk at an angle of 35°, with levels at 50 and 100 feet deep, had been cleaned out and retimbered to a depth of 60 feet when visited July 10, 1930, and the drain adit and most of the 50-ft. level had been reclaimed. This level has a total length of 730 feet including the drain adit and 525 feet of drifting on the vein, which has been stoped from there to the surface for a reported length of 400 feet. The vein strikes north and dips 30° to 45° east, varying in width from 2 to 12 feet. On the 100-ft. level, work is said to have not yet reached the vein. Most of the work was done 35 or more years ago when the mine was equipped with an 8-stamp mill. The operators have no definite record of the tonnage or value of past output. Three men were employed and there was no new equipment on the claims when visited.

Bibl: State Mineralogist's Reports XII, p. 317; XIII, p. 501; XV, p. 444.

Easy Money Prospect is in the SW¼ of NW¼ Sec. 17, T. 19 N., R. 7 E., and contains 40 acres, patented. J. P. Bollinger in charge. It is two miles north of Challenge by road.

Formerly worked by Harvey, who made a production of a few thousand dollars, it was sold by him several years ago and the present stock company was formed. The old workings were cleaned out and a little new work has been done. There has been no production by the present company, and no ore has been proved.

A crosscut adit 505 feet long cuts a vein of bluish quartz eight inches wide. An ore shoot 20 feet long was stoped from here to the surface, a distance of only 50 feet on the dip, by former operators. From this place the adit was run south 320 feet to a shaft 93 feet deep; thence 35 feet south, and also from the shaft 28 feet west to prospect narrow seams. The one cut on the west was followed north and south 100 feet but widened to only three inches. No. 3 adit, 318 feet long and 72 feet deep at the face, is also on a narrow quartz seam. All the workings are in the upper, decomposed part of what was evidently diorite or a similar igneous rock, and the narrow seams and veinlets of quartz evidently occupy joints or shrinkage cracks.

There is a small home-made 6-stamp mill, with 75-lb. stamps on the property. Second-hand automobile engines are used to run the mill and the hoist at the vertical shaft.

Horseshoe Mine is a mile and a half northeast of Challenge in SW¼ Sec. 21, T. 19 N., R. 7 E. Owners, Fred Clemons and Mrs. Clemons, Browns Valley, and Joseph Supple, Portland, Oregon. Recently a lease and option to purchase was given to I. O. Walberg who formed the *Walberg Mining Corporation.* This company tore down the five stamps which had been previously erected and started to install ten stamps but has lately become involved in financial troubles and at present (July 15, 1930) labor liens and other claims have been filed against the property and company and work has been stopped pending court action.

The vein, which pinches and swells but averages about 20 inches wide, strikes north and dips west between hard walls of schist. Many years ago it was prospected by a shaft 90 feet deep from which Clemons states he took 23 tons of ore of such good grade as to justify further prospecting. In 1920–21 a crosscut adit was run 600 feet to the vein at a depth of 200 feet and a drift was run 220 feet north following the vein. A 5-stamp mill was erected and a connection made from the adit with the shaft, but only a few small lots of ore were milled before the mill burned down. The reported yield from some of this ore appears to justify further work.

The five stamps had been set up again after the fire, and would have been sufficient for milling, at least until a tonnage of ore large enough to justify more milling capacity had been definitely blocked out. Water sufficient for milling can be had only in winter and spring under present conditions.

Kingbird Mine is a mile northeast of Clipper Mills. Some work has been done on both the *Little Kingbird* and the *Big Ledge* or *Kingbird,* which are about a mile apart. The Little Kingbird vein, on which the last work was done in 1921 and 1922, strikes north and dips east, varying in width from one foot to nine feet, but averaging three feet. A shaft was sunk upon it to a depth of 125 feet and a crosscut 350 feet to vein, with a drift 225 feet long on vein, connects with the shaft at a depth of about 100 feet. Between December, 1921, and March, 1922, about 700 tons of ore was milled in the 5-stamp mill. According to the foreman, Goeken, it averaged $7 a ton. No work has been done since.

On the Big Ledge, which is 20 feet wide, only a little shallow work was done years ago.

Mount de Oro Mine is in the S½ of SW¼ Sec. 9, T. 19 N., R, 7 E., one-half mile southwest of Woodleaf. It contains 80 acres patented and two unpatented mining claims. The owners are Wm. Beik, Challenge; Leslie Crouch, Chico, and Jos. Supple, Portland, Oregon. It is under lease and option to Mt. de Oro Gold Mining Company, a Nevada corporation. Riley W. Self, secretary. Allen G. Fraser and Collins are planning to take over the lease and option.

The prospect was worked in a small way ten years ago by Wm. Beik, Jos. Supple et al., at which time about 50 tons of ore was taken out and milled. Later a mill was built and 500 tons of ore is stated to have been milled and according to Beik yielded $8 a ton in free gold, with an equal amount lost in the tailing, as there were no concentrators in the mill, and the ore carries considerable sulphide of good grade. The present company made a mill run of 40 tons which confirmed the good grade of the ore and the high tailing loss, according to Self.

The vein, which strikes N. 15° W., is reached on the lowest level by a crosscut adit 650 feet long, with 40 feet of drifting on the vein. At this depth, the inner workings show comparatively fresh wall rock and vein matter, devoid of the leaching and oxidation noted higher. The wall rock is gabbrodiorite of rather coarse texture and the vein of bluish quartz thickly springled with pyrite. In the upper workings, the vein has been leached and kaolinized; the action of air and surface water have oxidized the pyrite, forming from this an acid solution which has leached out the soluble ingredients of the vein and walls

leaving a siliceous rock carrying free gold and a little iron oxide. The vein varies from two to five feet wide on the north but pinches to a width of a few inches in the southeast end of workings. The ore shoot had been opened for a length of 90 feet on the 120-ft. level, which connects by a raise of 50 feet on dip, with the lowest adit, and with a shaft. Assays, pannings and mill tests all indicate that the ore shoot is good grade ore.

The mill, which is nearly new, contains five heavy stamps and a 25-h.p. semi-Diesel engine. A Wilfley concentrator has been added lately, but little else has been done the past year. The mine was idle in July, 1930, pending the proposed transfer to Fraser and Collins.

Red Cross Mine is in Sec. 29, T. 18 N., R. 7 E., one mile north of Dobbins at an elevation of 1950 feet. Red Cross Mining Company, 620½ I street, Sacramento, or Dobbins. Edward S. Van Dyck, president. The company is working on a tract of 160 acres upon which shallow mining was carried on by previous operators. A former company began prospecting in 1915 but went out of existence in three years. The present concern was incorporated in 1924 in Nevada and has been working in a small way since.

Two small flat veins, lying only 20 and 40 feet below the surface, were worked through adits until one of them steepened. It has been followed with an inclined shaft to a depth of 130 feet on the dip. It strikes N. 60° E. and dips 45° W. The width varies, being often less than one foot, but a width of three to four feet is mined on the hanging wall side which is also said to carry some gold. Both walls are soft, rotten gabbrodiorite and stopes have to be timbered with square sets and lagging. The country rock is soft and altered as deep as mining has gone. The 60-ft. level or drain level No. 2 is about 650 feet long connecting with the shaft. It is in the footwall of the flat vein, which, according to the company's assay record, gave assays of from $4 to $24 a ton for an average width of one foot. The 90-ft. level has been run 50 feet southwest and 137 feet northeast from the shaft. From this level up to the adit level on the northeast side of the shaft the vein has been stoped out and the level has caved. From the southwest end of this level an air raise run through the hanging wall to the surface is said to have shown a gold value of $1.44 a ton, every fourth bucket having been milled. This rock is altered so far that is is easily picked and shows rusty and kaolinized seams. The 130-ft. level, running 60 feet northeast and 85 feet southwest, yields about 40 g.p.m. of water, which is used partly for milling. Stoping is going on above this level. Other shallow workings include the No. 1 adit, running 200 feet northwest, and a number of shallow shafts and pits, said to indicate possibilities of a large, low-grade orebody. Ore is raised in a bucket of 500 lbs, capacity, operated by a 20-h.p. electric hoist.

The mill contains two stamps, which are said to handle 15 tons of the soft, decomposed wall rock making up most of the tonnage milled, in 24 hours. It is operated only 8 hours a day at present. After crushing to 20-mesh, ore passes to two Devereaux agitators, where it has 24 hours contact with cyanide solution; the solution then passes to clarifiers and zinc boxes. A recovery of 90% is claimed, of which 80% is by cyanide, no amalgamation plates being used. One-half

pound of cyanide and five pounds of lime are used per ton of ore. Ore is reported to be of fair grade. Four men are employed.

Too Handy Mine is in SW¼ Sec. 22, T. 16 N., R. 5 E., on the north side of the Yuba Consolidated Gold Fields holdings about one mile from Browns Valley. *Hammon Engineering Company* is doing the prospecting work for the owners. Thomas Hamlyn, superintendent.

Work was started by the company after gold-bearing quartz had been dug from the river by one of the dredgers. The new shaft, through which all work is being done, is 1000 feet S. 30° E. from the old shaft. The present operators reclaimed the old shaft and did some prospecting there. The new shaft was then sunk 410 feet vertically. Unusually hard rock was encountered and this work was expensive. One level was turned at a depth of 350 feet and the vein has been followed about one-half mile in a southeasterly direction. The vein occurs in, or has for one wall, a narrow belt of graphitic, schistose dike material, lying in the series of greenstone rocks called 'amphibolite schist.' There is no true Mariposa clay slate here, but the graphitic dike material is probably Calaveras. The greenstone shows several variations, including coarse, granular gabbro or diabase and a green and grey felsitic rock with flow structure, both on the hanging wall side, with grey dike rock streaked by black on the footwall. The black and grey schist occur together in bands and streaks without any contact between. Granodiorite about 800 feet wide cuts across the mine workings, without much disturbance. The vein has been crushed in places by a post-mineral strike fault. It is of fair width so far as followed, but assays are reported to show it spotted and irregular in gold content. The sulphides (principally pyrite) are said to carry most of the pay.

Equipment includes hoist operated by 75-h.p. motor, centrifugal pump with 50-h.p. motor and air compressor. As the workings are under Yuba River, 350 g.p.m. of water has to be pumped steadily. There are good camp and office buildings. Twenty men were employed when visited.

Work at this prospect was stopped August 4, 1930. The latest work included a winze sunk 240 feet from the 350-ft. level, with some drifting from the bottom of it.

GOLD (PLACER MINES)

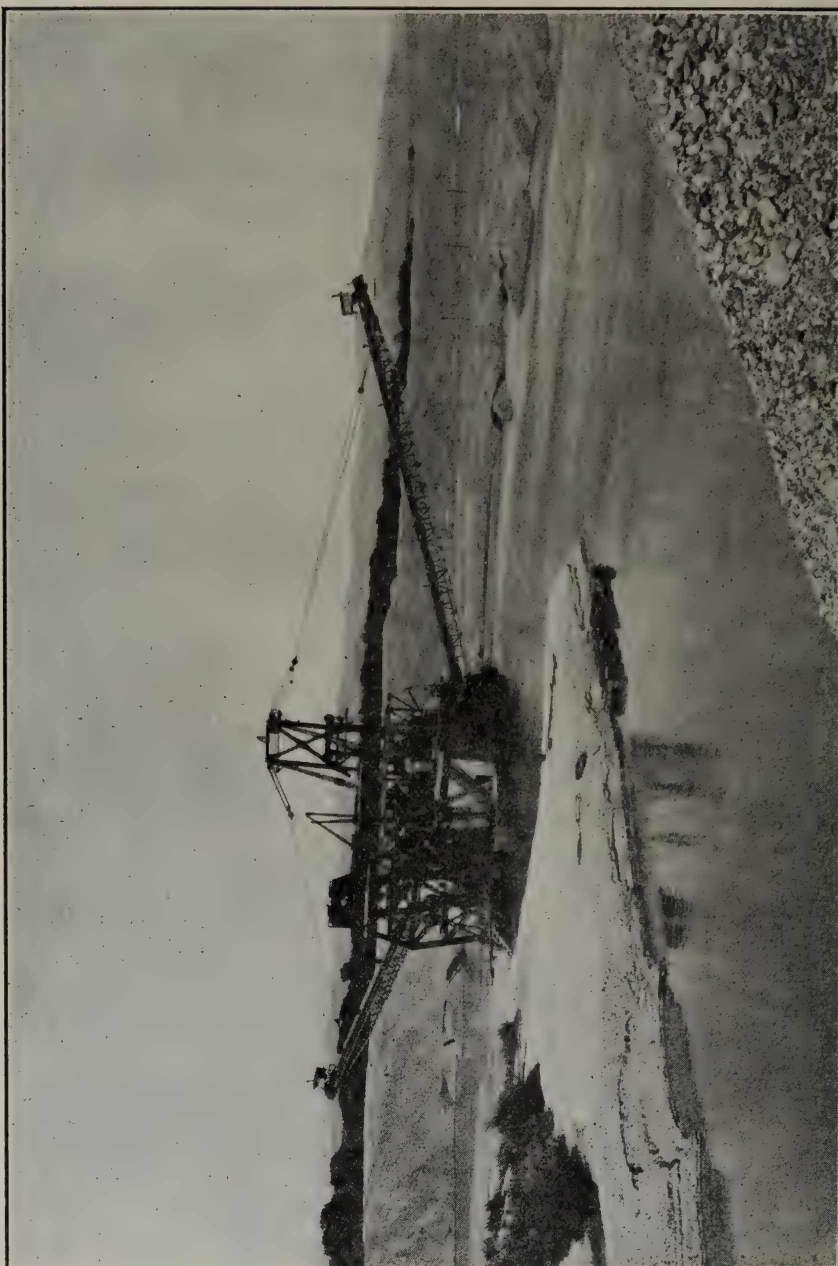
The production of gold from surface, drift and hydraulic mines has been small since 1914. Surface mining consists principally of summer work done along the banks and gravel bars of Yuba River below Smartsville by lone miners or small groups who have produced from \$2,000 to \$5,000 in all annually in this way from the tailings washed down each year. Several small drift mines, worked in a desultory way principally in the same district when water for washing is available in winter, have produced from \$4,000 to \$7,500 annually in late years. A long series of poor water seasons has hampered placer mining. There has been practically no hydraulic mining in Yuba County since 1917, when \$5,934 was produced. The extensive gravel deposits at Smartsville, formerly worked by the hydraulic process, have lain idle in late years expect for the desultory drift mining mentioned above. The Smartsville hydraulic diggings yielded an estimated total of

$13,000,000, at the average rate of 37 cents a cubic yard, up to 1877. At Timbuctoo, Smartsville and Mooney Flat (the last named in Nevada County) it is estimated that 44,800,000 cubic yards have been hydraulicked and 33,400,000 cubic yards are available at present. The dredging fields at Hammonton on Yuba River owed its wealth in gold largely to the fact that for many miles the modern Yuba River followed the course of the Neocene Yuba, deepening the ancient canyon and reconcentrating and sweeping downstream to the valley the gold content of the old stream from near French Corral to Mooney Flat, and from Timbuctoo westward for several miles.

GOLD DREDGING

The Yuba River dredging district, which has been the most productive in the state, extends along the river from the mouth of the rocky canyon to a mile west of Marigold, having a total length of about 7½ miles and a width of one to two miles. Because of the output of this district alone, Yuba County for years led all the counties of the state as a producer of gold. Dredging on Yuba River began in 1903 under the direction of W. P. Hammon and R. D. Evans. In 1905 their interests were acquired by Yuba Consolidated Gold Fields, which became the principal operating company here. This company has operated 18 dredgers in all. Marysville Dredging Company began work in 1906 and worked five dredgers, operating in the lower part of the field around Marigold until February 10, 1925, when they sold out to Yuba Consolidated Gold Fields. In 1916 Pacific Gold Dredging Company began work with one dredger at the upstream edge of the field and worked for several years, finishing their ground March 10, 1923.

The total area of proved dredging ground in Yuba River district was about 4000 acres. From 1907 to the end of 1929, the total gold production of Yuba County has been nearly $67,000,000. When it is considered that nearly all of this gold came from dredging the 4000 acres mentioned (the production of other mines being small) a good idea may be formed of the richness of the field. The depth of ground that paid to dredge varied from 45 feet, on the fringes of the lower end of the field, to about 100 feet on the upper end. On the north side the dredgers now working are striking 'bedrock' at 50 to 60 feet in depth. The upper portion of the gravels in the flood channel, to a depth of 40 feet, consist of old tailings from the hydraulic mines formerly operated farther upstream. This generally carried not over six cents in gold per cubic yard. The so-called 'bedrock' under the pay gravel is the usual volcanic ash from the Sierra Nevada, altered and consolidated in some places. True bedrock was not reached in the lower part of the field. Drilling indicated two pay channels south of the present river, the older running southwest, with a poor streak between it and the upper channel which trended northwest. The gravel is generally medium to fine in size, and free wash, so that conditions have especially favored large scale operations at low unit cost. The peak of production occurred in 1921, when the gold yield of Yuba County was $4,738,248. For the entire period, 1907 to 1928, inclusive, the annual output has only twice dropped below $2,000,000 (in 1907 and 1924).



Bow view of Dredge No. 16, with two stackers, used to throw up restraining walls and to level the channel beds when dredg-

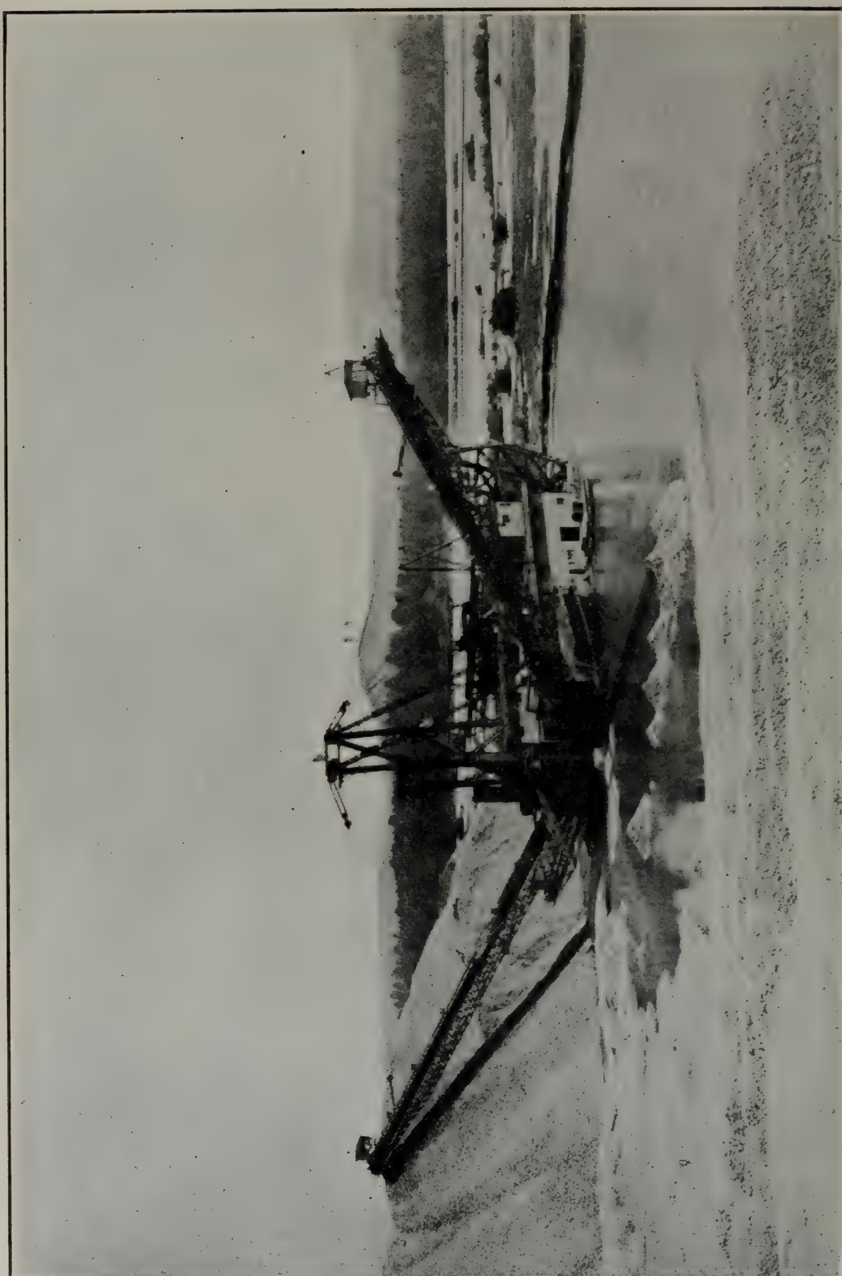
From now on, however, gold production in that county will rapidly decrease.

Gold Dredges, Incorporated, Limited, quit operation of the Garden Valley dredger July 1, 1930. The land dredged is on Willow Creek about five miles from Camptonville by road. The deposit extends along the creek nearly a mile and is composed in large part of hydraulic mine tailings from the Depot Hill Mine, but it is claimed there is some gravel in the creek that has never been worked on account of water and lack of grade. According to H. G. Kumle, who drilled the ground and helped start operation, the possible yardage of deposit was 2,300,000 cubic yards, of which 700,000 cubic yards have been dredged. From an indicated average value of 15.31 cents a cubic yard for the first five months, an average recovery of only about 65% is reported. The gravel is fine to medium in size.

The dredger was commissioned September 1, 1925, by Kumle and Kassabaum. Operation has been intermittent, the total time of working having been 16 months under various operations, indicating a monthly capacity of about 44,000 cubic yards. It was a second-hand outfit carrying 43 buckets of 4½ cubic feet capacity and equipped with electric motors totaling 175 horsepower. It dug 16 to 20 feet below water level. Originally, it was said to lack sufficient table space but at present carries about 700 square feet of tables besides the save-all table. Seven men were employed when operating, but the dredger was idle when visited July 8, 1930, electric power having been cut off.

Yuba Consolidated Gold Fields. Main office, Boston, Massachusetts. Rene E. Paine, president. Charles W. Gardner, superintendent, Balfour Building, San Francisco. California operations are under management of Hammon Engineering Company, San Francisco. G. C. Aaronson, acting superintendent, Hammonton. This has been the largest and most productive gold dredging concern in the state. As mentioned above, the company was organized in 1905 by W. P. Hammon and R. D. Evans, with Hammon as managing director. The operations have been frequently described, particularly in Bulletin 85 of the State Mining Bureau (1918) and in the Fifteenth Report of the State Mineralogist (1915).

Nineteen dredgers in all have been operated by this company and its predecessors. Of these, the Yuba No. 1 and No. 2 were commissioned by Hammon and Evans in 1903 and 1904. Made by Bucyrus and by Western Engineering Construction Company, they had buckets of six cubic feet capacity, with shaking screens, and were capable of digging to a depth of 60 feet below the water line. From Yuba No. 3 to Yuba No. 12, inclusive, commissioned between 1905 and 1908, all had from 89 to 96 close-connected buckets of 7½ cubic feet capacity and revolving screens. These dredgers all had horsepower ratings of from 350 to 405, could dredge to a depth of 64 to 68 feet below the water line, and had monthly capacities of 125,000 cubic yards. Yuba No. 13, commissioned in 1910, was the first of the new series of large dredgers. It had 89 close-connected buckets of 16 cubic feet capacity, and its rated monthly capacity was 300,000 cubic yards. Yuba No. 14, commissioned in 1913, had the first all-steel hull. It carried 96 buckets of 16½ cubic feet capacity and could dig 78 feet below water



Stern view of Dredge No. 16 of Yuba Consolidated Gold Fields, operating near Hammonton on Yuba River. Photo by courtesy of G. C. Aaronson, acting superintendent, Yuba Consolidated Gold Fields.

level. This dredger worked 14 years, and in this connection the superintendent states that none of the company's steel-hulled dredgers has been worn out. Yuba No. 14 cost about $450,000 and the cost for each succeeding dredger increased. Yuba No. 15 to Yuba No. 18, inclusive, were similar in type and size to No. 14, except for greater depth capacity, having 98 buckets and digging 83 to 84 feet below water level.

Yuba No. 16 (see photo) is equipped with two tailing stackers, in order to comply with regulations of the California Debris Commission regarding the disposition of tailing along streams tributary to Sacramento and San Joaquin rivers. Under a working agreement with that commission, whereby the gold dredging operations of the company and the commission's plans for straightening the Yuba River channel are coordinated, the double-stacker dredge digs two cuts each 400 feet wide, stacking tailing on each side of the cuts, which are thus separated by high rock piles. It is said that in ten years past, Yuba River has lowered its bed at Marysville eight feet by scouring.

When this company took over the holdings and plant of Marysville Dredging Company February 10, 1925, it renamed Marysville No. 5 dredge the Yuba No. 19. This has 87 buckets of 16 cubic feet capacity with a maximum rating of 872 horsepower, a depth capacity of 68 feet and is capable of a monthly output of about 400,000 cubic yards. The other large dredges (from Yuba No. 13 on) have ratings over 700 horsepower with digging motors of 440 horsepower each. Except for Yuba No. 19, which was built by Union Iron Works, San Francisco, all the dredges used by this company from Yuba No. 10 to Yuba No. 18, inclusive, were built by Yuba Manufacturing Company, a subsidiary of the dredging company which formerly had a plant at Marysville but has moved to San Francisco. This company has made dredges also for buyers outside the United States, including some for the present Russian government, for use in the platinum fields.

The exceptionally favorable dredging conditions with such a depth of free-wash gravel of small and medium size and the large scale of operations have been conducive to low operating costs. The following are figures for yardage handled, gross returns, costs, etc., for the period since 1915:

OUTPUT, OPERATING COSTS, ETC., YUBA CONSOLIDATED GOLD FIELDS, 1916-1929

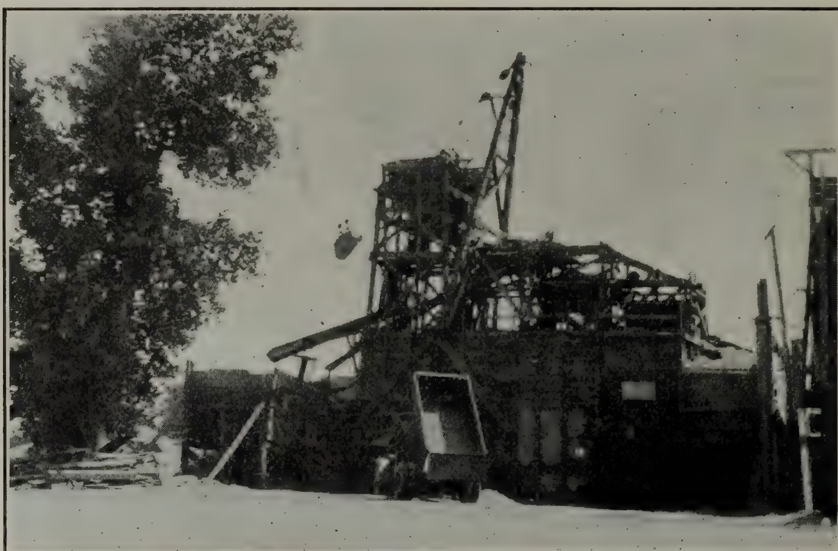
Year	Yardage	Average yield, cents	Net total yield	Operating cost, cents a yard	Profits
1915-16	17,750,000	12.02	$2,133,528	4.27	$1,374,868
1916-17	18,490,000	14.86	2,748,197	3.99	2,009,500
1917-18	15,460,000	18.42	2,849,220	4.90	2,090,691
1918-19	15,996,000	19.49	3,117,791	7.22	1,962,426
1919-20	23,523,000	13.66	3,213,213	6.99	1,645,548
1920-21	23,148,000	15.16	3,510,170	7.48	1,779,584
1921-22	26,035,000	14.65	3,814,645	6.94	2,006,879
1922-23	24,039,000	8.50	2,043,305	4.55	1,056,863
1923-24	23,381,276	11.10	2,596,433	4.50	1,543,128
1924-25	17,490,671	9.43	1,649,010	5.19	739,928
1925-26	----------	----------	----------	----------	----------
1926-27	----------	----------	----------	----------	----------
1927-28	24,543,176	13.19	3,232,794	4.71	2,077,871
1928-29	24,948,295	8.81	2,196,846	4.53	1,066,124

The total yardage dredged from 1904 to February 28, 1929, was 426,289,205 cubic yards, which yielded a gross return of $58,254,035.95 and a net operating profit of $35,721,560.33.

Bean Boys Hydraulic Mine is one mile east of Clipper Mills and comprises in all 150 acres. R. J. Bean, Clipper Mills, owner.

In Penny Ravine, a branch of Hampshire Creek, there is a length of one-half mile where the gravel is 10 to 12 feet wide with a bank 10 feet high of which the two or three feet next the bedrock is claimed by the owner to carry pay. The gravel is sub-angular with some quartz and some boulders 1-man size. The bedrock is decomposed gabbrodiorite.

In Clipper Ravine, where a length of one-fourth mile has been worked, the upper end of workings is 30 to 40 feet wide and the work was heading up the ridge in the direction of what may prove to be a remnant of an old channel, judging by the quartz boulders showing at the surface. The property has been idle most of the time since the last report but the owner plans work this season. The upper ditch with a capacity of 400 miner's inches gives a fall of 75 to 200 feet on the



Hemstreet and Bell's sand plant on Yuba River near Marysville.

Clipper Ravine ground. The water supply will come from Grizzly Creek, requiring a mile of ditch. Bean plans to finish an hydraulic fill reservoir and a tailing dam of the same kind this season.

MISCELLANEOUS STONE

The Yuba River at Marysville carries large quantities of sand with only a small amount of gravel. The sand there carries a larger proportion of coarse-sized grains and is sharper than farther downstream. It is favorably known among contractors and engineers for highway construction and other concrete work, for gunite work and plaster sand. Small tonnages of pea gravel, concrete mix and washed gravel are also marketed. Three plants are at present in operation taking sand from the river.

At Hammonton and Marigold, on Yuba River 12 miles by road upstream from Marysville, lie immense piles of cobblestones, sand and

gravel left by the gold dredgers. This is suitable for concrete work as the rocks are hard, fresh and clean breaking. No use is being made of this material at present because of lack of railroad facilities, but it forms a reserve which can be utilized at any time in the future. Over 400,000,000 cubic yards of gravel was dredged by one company alone near Hammonton.

Hemstreet and Bell. Office, 501 Eleventh street, Marysville. Sand and gravel plant is on Yuba River east of Seventh street.

Sand with a small amount of gravel is dug from Yuba River with a drag-line outfit using a Pioneer bucket of one-half cubic yard capacity, operated by a 50-h.p. electric motor. The sand is dumped into a hopper, passing by gravity to a series of revolving screens which separate the different grades of sand and gravel. Concrete sand, plaster sand, pea gravel, and washed gravel are produced. The capacity of the plant varies with the distance the sand is carried by the bucket, but is at least 125 to 150 cubic yards daily. Storage is in bins from which trucks are loaded, and in outside stock piles. There is no rail connection to the plant. Three men are employed.

The company also uses small portable outfits on caterpillar mounts for digging sand and gravel during the low-water period at nearby places along the river.

Marysville Sand Company, Incorporated. Plant on south side of Yuba River opposite Marysville. Idle in July, 1930.

Pacific Coast Aggregates operates the plant at Marysville formerly belonging to Pratt Building Material Company, which was one of the companies consolidated in 1929 to form the new firm. The plant is on Yuba River at the

Sand plant of Pacific Coast Aggregates, Inc., at Marysville.

south city limits. F. R. Lantz, local superintendent. Material is dug from an unpatented mining claim crossing the river.

A Sauermann dragline outfit operated by a 75-h.p. Washington hoist using electric power digs sand and gravel from the river and delivers it to the top of the washing plant, where it is screened and washed and passes to settling tanks, and to storage bins. Plaster sand, carrying sizes up to one-eighth inch, and concrete sand up to seven-sixteenths inch size are the principal products. For gunite work sand must be dried in open bins. Small quantities of pea gravel and washed gravel are produced. The plant is served by spur track, permitting loading of railroad cars. Four men are employed and the capacity is about 400 tons a day.

The river during high water replenishes the supply of material by filling the pits dug in summer at the different plants.

Pratt Building Materials Company. (Company now consolidated with others to form Pacific Coast Aggregates, which see.)

Yuba River Sand Company. A. L. Brownlee, manager, and W. C. McBurney, superintendent. Office and plant on Yuba River at Marys-

Plant of Yuba River Sand Company at Marysville.

ville. This plant was leased to Pacific Coast Aggregates up to April, 1930, since which time the owners have resumed operation. It is the company's plan to rebuild the plant during the present year, with heavier machinery, a change in the method of digging and washing, and increased capacity.

At present a clamshell bucket of $1\frac{1}{4}$-cubic yards capacity run by a 75-h.p. electric motor and operated from a derrick moves sand from the river to the double screen, which runs under water, giving products through one-eighth and seven-sixteenths inch perforations. A second screening of the gravel gives pea gravel and wash gravel up to $1\frac{1}{2}$-inch size. Bucket elevators raise sand and gravel to bins from which railroad cars can be loaded. A separate open bin is kept for drying sand for

gunite. Concrete sand, plaster and brick sand, concrete mix, pea gravel and wash gravel for roofing, etc., are produced. In summer a drag-line scraper is used to move sand to where it can be reached by the clam-shell bucket. Four men are employed and a capacity of 1000 tons a day is claimed under good working conditions. When visited the plant was only producing a fraction of this amount on account of repair work.

PLATINUM GROUP METALS

Platinum, osmiridium and iridium have been produced as by-products of gold dredging for many years, although no complete statistics are available. These metals occur in very small quantities compared even to the gold content of the gravels, but the county has been the largest producer of them in the state because of the immense quantity of gravel washed. In the middle part of the field, one ounce of platinum group metals was recovered for each 50,000 cubic yards of gravel handled. In the lower section, around Marigold, only one ounce of the metals was produced for 380,000 cubic yards dredged.

The metals occur in very fine grains and thin flakes. Assays taken from lots of several hundred ounces over a period of several years showed 60.48% to 69.15% platinum, 14.67% to 18.96% osmiridium, and in cases of separate assay for iridium, 15.27% to 16.37% of that metal. The largest recorded annual production was 314 ounces in 1916, but since then the largest output was 189 ounces in 1918 and it has been less since, with the curtailed scale of operation incident to the exhaustion of the richer gravel.

Platinum group metals have been noted in the concentrate from some of the hydraulic mines in the county, but there is no record of production from such sources.

SAN FRANCISCO FIELD DIVISION

C. McK. Laizure, Mining Engineer

There is no report from the San Francisco Field Division, as the present series of county reports is complete for this district.

LOS ANGELES FIELD DIVISION

W. B. TUCKER and R. J. SAMPSON, Mining Engineers

SAN BERNARDINO COUNTY

History.

This county, which is the largest in the United States, was created by an act of the Legislature in April, 1853. In spite of the fact that in 1893 part of its territory was allocated to the new county of Riverside, its present area of 20,157 square miles exceeds that of the states of Massachusetts, Connecticut, Rhode Island and Delaware combined. It was named for San Bernardino of Sienna, by the Franciscan priests who visited the valley south of the San Bernardino Range on May 20, 1810.

The city of San Bernardino was founded by Mormons from Salt Lake City in 1851.

Location and Description.

San Bernardino County lies in the southeastern part of California. It is bounded on the east by Arizona and Nevada, on the south by Riverside County, on the west by Los Angeles and Kern counties and on the north by Inyo County.

Of its area approximately 18,500 square miles is desert; the remaining 1657 square miles consists of the timbered south slope of the San Bernardino Mountains and a fertile valley which forms a part of the citrus belt of southern California. Its boundaries embrace perhaps 85 to 90 per cent of the area known as the Mojave Desert. This desert area is an arid waste of land, but it is far from being a level plain, spotted with sand dunes. It might be described as a succession of broad valleys between more or less continuous mountain ranges. Out of the floor of these valleys rise many isolated rugged buttes as well as low, rounded hills.

Elevations in the county range from approximately 350 feet to 11,485 feet above mean sea level. The lower elevation is at a point on the Colorado River in the southeastern corner of the county, while the highest one is at the top of San Gorgonio Mountain in the San Bernardino Range. Other high points are San Bernardino Peak, 10,630 feet, and Sugar Loaf Mountain, 9842 feet, both of which are in the San Bernardino Mountains.

Many topographic sheets pertaining to portions of San Bernardino County have been published by the United States Geological Survey and data of inestimable value on the history, topography, geology and water supply of this county are contained in Water Supply Paper 578 and accompanying maps, published by the same department. This publication is out of print, but may be consulted in the larger public libraries.

Transportation.

Lines of The Atchison, Topeka and Santa Fe, the Union Pacific, Southern Pacific, and Tonopah and Tidewater railroads cross the county, affording direct communication with trade centers and seaports.

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SAN BERNARDINO COUNTY—MINERAL PRODUCTION 1880–1930.

Year	Gold value	Silver, value	Copper Pounds	Copper Value	Lead Pounds	Lead Value	Borates, value	Gypsum Tons	Gypsum Value	Salt Tons	Salt Value	Cement Barrels	Cement Value	Lime Barrels	Lime Value	Limestone Tons	Limestone Value	Brick M	Brick Value	Marble Cubic feet	Marble Value	Miscellaneous stone, value	Gems value
1880																							
1881	$9 000	$100 000																					
1882	20 000	150 000																					
1883	30 000	1 050 000																					
1884	32 000	2 550 000																					
1885	23 000	2 363 436																					
1886	56 461	1 204 760																					
1887	27,859	1,133 268																					
1888	25,000	1,200 000																					
1889	10 737	621 820																					
1890	17 335	793,465																					
1891	62,47[illegible]	711 157																					
1892	47,037	67 072																					
1893	158 000	447 020																					
1894	130 12[illegible]	148 243					$726 500			1 000	$3 000	8 000	$21 600	40 000	$32 000	5 000	$6 250					$31 622	
1895	131 [illegible]	213 410					555 [illegible]			3 841	20 101	16 283	32 55[illegible]	87 [illegible]	87 674	3[illegible] 000	36 000					37 672	
1896	96 723	130 714					650 500			3 000	15 000	9 000	27 000	37 427	34 977	17 500	17 500			500	$3 000	28 476	
1897	100 373	54 407					1 180 000					15,000	66 000	12 000	12 000								
1898	201 512	32 000					1 120 000					50 000	150 000	50 000	35 000	6 600	6 600	2 000	$16 800	1 200	8 000	15 040	
1899	164 5[illegible]	125 663	1 369 878	$2[illegible]			1 136 000					60 000	180 000	16 000	16 100	14 440	14 510	1 000	8 000	4 500	625	11 275	
1900	247 [illegible]	172 750	1 020 000	[illegible]7 600	10 000	$400	939 341					52 000	121 000	26 [illegible]	3[illegible]	7 067	7 067					65 757	$20 000
1901	330 6[illegible]	57 104	[illegible]6 000	7 875	500	2[illegible]	598 130					71 800	159 842	38 7[illegible]	[illegible]	51 210	76 710					16[illegible] 777	20 000
1902	394 [illegible]	58 072	338 480	41 0[illegible]	59 340	2 076	2 198 600					96 000	273 000	76 [illegible]	[illegible]5 832	48 980	51 578	60	1 800	6 005	15 600	1[illegible]2 400	11 600
1903	381 197	50 199	60 400	7 852	14 000	504	405,000					100 000	157 000	[illegible]	28 6[illegible]	52 813	61 [illegible]	100	8 000	78 000	41 000	[illegible]81	10 000
1904	595 [illegible]	13 025	160 477	17 27[illegible]										25 [illegible]	21 500	28 421	42 775	2 500	17 500	11 116	53 400	158 656	
1905	473 803	19 505	52 603	8 206										17 024	14 740	27 387	51 395			40 100	40 000	14[illegible]	65 000
1906	354 830	33 765	514 031	[illegible] 237										2[illegible]	17 14[illegible]	1[illegible]	3[illegible]	1 800	13 500	[illegible] 200	25 000	18 476	
1907	158 [illegible]76	81 [illegible]	511 [illegible]	10[illegible]	34 211	1 [illegible]								8 [illegible]	8 600	74 700	131 188	1 957	15 555	6 482	29 940	147 [illegible]	
1908	150 511	35 704	516 9[illegible]	71 [illegible]	4[illegible] 570	17 218		2[illegible] 000	$70 000	90	650					104 [illegible]	97 460	1 079	7 350	150	500	231 242	200
1909	40,071	1[illegible] 571	310 30[illegible]	40 4[illegible]	310 200	13 254		12 500	43 000	1 500	14 000					[illegible]	41 395	1 709	11 [illegible]	50 000	127 000	173 777	200
1910	57 093	1[illegible] 164	5 412	68[illegible]	134 312	5 972		[illegible]1 515	71 357	3 000	[illegible]000					[illegible]4 610	157 715	1 914	11 460			95 126	1 120
1911	1[illegible]7 167	15 542	[illegible]	[illegible]	161 [illegible]	7 [illegible]		[illegible]0 584	66 505	3 600	13 800					21[illegible]	177 050			1[illegible]5	465	167 213	
1912	[illegible]	[illegible]	1 [illegible] 185	[illegible]	[illegible]	[illegible]		2[illegible]	6[illegible]	3 [illegible]	[illegible]2 000	[illegible] 631 000	[illegible]			[illegible]	[illegible]	1 [illegible]40	8 [illegible]			580 824	450
1913	3[illegible]6 521	41 41[illegible]	[illegible]	47 107	279 241	1[illegible]		[illegible] 000	74 000	[illegible] 019	10 5[illegible]			1[illegible]	11[illegible]	[illegible]	[illegible] 464	[illegible]50	2 100			364 312	550
1914	20[illegible]	[illegible]	[illegible]	[illegible]	15 11[illegible]	1 [illegible]		17 [illegible]	40 150	45[illegible]	[illegible]			[illegible]57	[illegible] 100	21 000	[illegible]0 880	[illegible]	1 250			111,978	
1915	41[illegible]	[illegible]	2[illegible]40	10 67[illegible]	1[illegible] 183	[illegible]				[illegible]	[illegible]24	[illegible]	[illegible] 000			18 500	[illegible]	4[illegible]	[illegible] 100			176 528	
1916	[illegible]	11[illegible]	1 [illegible]	[illegible]	[illegible]	[illegible]				[illegible]	[illegible]	1 036 000	1 [illegible]	[illegible]	4 [illegible]17	65 174	[illegible] 456					172 454	1 000
1917	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]						[illegible]	[illegible]									111 158	
1918	29 [illegible]25	88 712	1 58[illegible]	3[illegible]0 597	667 978	47 4[illegible]						1 027,035	1 453 [illegible]2			10 852	13 323					48 451	
1919	[illegible]	1[illegible]7 71[illegible]	[illegible]56 [illegible]	47 7[illegible]0	165 7[illegible]	5 607		19 61[illegible]	50 154			1 078,943	1,717,998									183 388	
1920	[illegible]	[illegible]	[illegible]	[illegible]01	11[illegible]	[illegible]270	44 [illegible]			202	1 220	1,681,283	3 051,079									169 991	
1921	[illegible]	[illegible]706	17 05[illegible]	[illegible]	22 81[illegible]	1 027	[illegible]			14 27[illegible]	67 78[illegible]	1 904 926	4,633,437			[illegible]1 86[illegible]	106 1[illegible]					145,572	
1922	[illegible]	[illegible]	13 [illegible]	1 81[illegible]	1[illegible]	615				12 222	54 250	2 770 953	4 150,430			2 200	7 800						
1923	[illegible]	[illegible]	[illegible]	1 [illegible]	34 [illegible]	2 113				17 350	65,550	3 554 764	8 478,012			5 85[illegible]	25 324					351,151	
1924	[illegible]	[illegible]	[illegible]	2 [illegible]	[illegible]	2 533				20 699	[illegible]3 791	4 354 119	7 571 370			14 375	45 137					355 946	
1925	157 [illegible]74	[illegible]	[illegible]21	[illegible]	61 1[illegible]0	5 [illegible]19				25 310	101 085	5 070 281	6 828 044	17 [illegible]	1[illegible],446	13 239	27 589					395 048	
1926	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]5 536	[illegible]				22 522	[illegible]	5 1[illegible]5 810	9 273 627	1[illegible]	[illegible] 310	11 226	49,504					40[illegible] 681	
1927	[illegible]	44[illegible]	1 [illegible]	[illegible]	12[illegible]	[illegible]						5 [illegible] 339	[illegible] 823,83[illegible]	12 170	62 363	550 011	348,384					[illegible]	
1928	[illegible],717	[illegible]2 741	[illegible]	15 [illegible]	38 097	[illegible]				42 244	19[illegible] 47[illegible]	4 [illegible] 353	7,137,600	14 [illegible]15	1[illegible],312	11,201	40,224						
1929	44 [illegible]	189 7[illegible]	[illegible]	11 [illegible]	53,532	[illegible]				21,949	11[illegible]	3 570 [illegible]	4,603,3[illegible]	19,145	77,340	15,526	40,753					[illegible]	1 [illegible]10
1930	[illegible]	[illegible]	[illegible]	[illegible]	45[illegible]5																	[illegible]	
Totals	$7[illegible]	$123 [illegible]	14[illegible]	$[illegible]	[illegible]	[illegible]	$1,1[illegible]6,245	$147 548	$490 1[illegible]6	$218 [illegible]45	$8[illegible]	$4[illegible],485	$78 812,157	$[illegible]1,730	$2,[illegible]08,594	$1,904,228	$2,011 342	$15,009	$125,721	$185 388	$343 076	$[illegible],155	$131,660

Miscellaneous and unapportioned

Year	Amount	Value	Substance
1904	4 000 cu ft	$2 000	[illegible]
1906	10 [illegible]	5 500	[illegible]
1909	[illegible] tons	3 [illegible]	Pottery [illegible]
1909		1 035 [illegible]	[illegible] (1908–1909)
1910	410 tons	4 [illegible]	[illegible] clay
1910	1 [illegible]8 000 gals	25 000	Mineral water
1911	[illegible]	[illegible]	[illegible]
1912	[illegible]	[illegible]	Pottery clay
1912	[illegible]	[illegible]	[illegible]
1913	4[illegible] gals	25 000	Mineral water
1913	[illegible]	[illegible]	[illegible]
1914	44 10[illegible]	[illegible]	[illegible]
1914	[illegible] tons	[illegible]	Mineral paint
1914	140 tons	400	[illegible]
1915	37 4[illegible] gals	7 3[illegible]	Mineral water
1915	5[illegible]	510 0[illegible]7	Tungsten concentrates
1915	39 8[illegible] lbs	4 9[illegible]	[illegible]
1915		62 1[illegible]	[illegible]
1916	7 500 cu ft	2,5[illegible]	[illegible]
1916	40 500 gals	6 [illegible]	Mineral water
1916	1 [illegible] tons	1 913 [illegible]	Tungsten concentrates
1916	[illegible]	94 716	Zinc
1916	707 06[illegible]	217 2[illegible]	[illegible]
1917		[illegible]	[illegible]
1917		187 9[illegible]	[illegible]
1917	235 tons	6,0[illegible]	[illegible]
1917	11 3[illegible] gals	1 [illegible]	Mineral water
1917	14 5[illegible] tons	2 049 [illegible]	Potash
1917	3 0[illegible] tons	37 000	Strontium
1917	1 [illegible] tons	2 447 726	Tungsten concentrates
1917	35 735 lbs	3 051	Zinc
1917		114 534	Brick, pottery clay, dolomite, feldspar, gems, gypsum, [illegible] mineral paint, salt, soda, talc
1918	270 tons	810	Dolomite
1918	601 506 gals	60 150	Mineral water
1918	27 515 tons	3 428 443	Potash
1918	110 tons	4 210	Talc
1918	2 9[illegible] tons	33 000	Strontium
1918	1 147 tons	1 911 [illegible]68	Tungsten concentrates
1918	2 [illegible] lbs	257	Zinc
1918		122 348	[illegible] granite, gypsum, [illegible] lime, magnesite, manganese, marble, mineral paint, salt
1919	[illegible]800 06[illegible] gals	32 006	Mineral water
1919	21 171 tons	1,670,919	Potash
1919	3 601 tons	19 845	Talc
1919		443 492	Borax, pottery clay, dolomite, gems, lime, tungsten
1920	95 tons	890	Pottery clay
1920	1 110 190 gals	150 720	Mineral water
1920	15 435 tons	1 082 037	Potash
1920		336 551	Dolomite, gems, granite, gypsum, [illegible] sandstone, soda, talc
1921	683 tons	22 050	[illegible]
1921	7 202 tons	211 067	Potash
1921	2 750 tons	43 375	Talc
1921		374 728	Pottery clay, dolomite, feldspar, [illegible] granite, gypsum, iron ore, lime, mineral water, [illegible] soda
1922		1,620,304	Borax, calcium chloride, [illegible] earth, gems, gypsum, [illegible] mineral water, potash, soda, talc, [illegible]
1923	830 tons	12 030	Clay (pottery)
1923	7 248 tons	1[illegible]	Talc
1923		2 270 [illegible]	Borates, calcium chloride, [illegible] gypsum, lime, mineral water, potash, [illegible] tungsten concentrates
1924	7 [illegible] tons	125 926	Talc
1924		2 720 243	Borates, calcium chloride, clay (pottery), fullers earth, gypsum, [illegible] mineral water, petroleum, potash, [illegible] (trona), tungsten concentrates
1925	1 540 tons	11 000	Clay (pottery)
1925		3 150 468	Borates, calcium chloride, fullers earth, mineral water, petroleum, potash, soda (trona), talc, tungsten concentrates
1926	[illegible] tons	10 605	Clay (pottery)
1926	[illegible] tons	73 721	Strontium
1926	[illegible] tons	14[illegible]	Talc
1926		3 381 15[illegible]	Borates, calcium chloride, fullers earth, magnesite, mineral water, petroleum, potash, [illegible] tungsten concentrates, zinc
1927	1 [illegible] tons	26 [illegible]	Fullers earth
1927	[illegible] tons	4[illegible]	Talc
1927		4 925 551	Borates, calcium chloride, clay (pottery), gems, mineral water, onyx, petroleum, potash, salt, silver, soda (trona), tungsten concentrates
1928	[illegible] tons	12,[illegible]5	Clay (pottery)
1928		5,873,0[illegible]	Antimony, borates, calcium chloride, fullers earth, gems, mineral water, potash, soda, talc and tungsten
1929	[illegible] tons	15 874	Clay (pottery)
1929		5,474,41[illegible]	Barytes, borates, calcium chloride, manganese, mineral water, potash, volcanic ash, soda, talc, tungsten
1930	0,3 tons	14 51	Clay (pottery)
1930		9 959 571	Barytes, borates, brick, calcium chloride, cement, fullers earth, gems, [illegible], manganese ore, mineral water, potash, salt, soda, talc, tungsten
Totals		$66,922 050	

[illegible]
[illegible]
[illegible]

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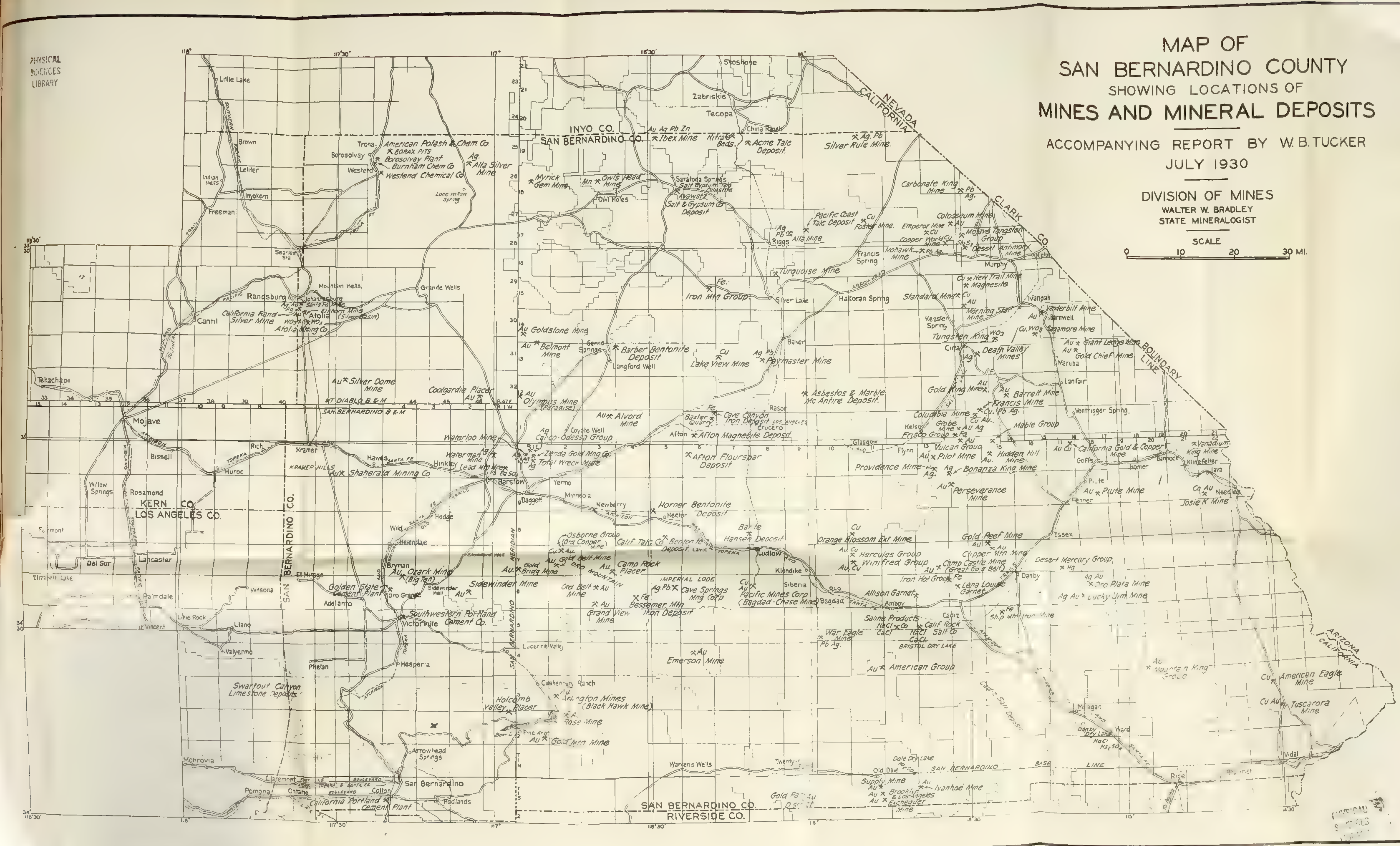

MAP OF
SAN BERNARDINO COUNTY
SHOWING LOCATIONS OF
MINES AND MINERAL DEPOSITS
ACCOMPANYING REPORT BY W. B. TUCKER
JULY 1930
DIVISION OF MINES
WALTER W. BRADLEY
STATE MINERALOGIST
SCALE
0 10 20 30 MI.
INYO CO.
SAN BERNARDINO CO.
KERN CO.
LOS ANGELES CO.
SAN BERNARDINO CO.
RIVERSIDE CO.
NEVADA
CALIFORNIA
CLARK CO.
BOUNDARY LINE
ARIZONA
CALIFORNIA
SAN BERNARDINO MERIDIAN
SAN BERNARDINO B. & M.
MT. DIABLO B. & M.
Barstow
Victorville
San Bernardino
Needles
Mojave
Randsburg
Trona
Baker
Ludlow
Amboy
Redlands
Colton
Daggett
Yermo
Hesperia
Lancaster
Silver Lake
Shoshone
Tecopa
Zabriskie
Cima
Goffs
Essex
Danby
Vidal
Rice
Kelso
Kramer
Hinkley
Hodge
Oro Grande
Adelanto
Phelan
Ontario
Pomona
Claremont
Monrovia
Arrowhead Springs
American Potash & Chem Co
Borosolvay Plant
Burnham Chem Co
Westend Chemical Co
Alta Silver Mine
Ibex Mine
Acme Talc Deposit
Silver Rule Mine
Iron Mtn Group
Barber Bentonite Deposit
Lake View Mine
Paymaster Mine
Silver Dome Mine
Coolgardie Placer
Olympus Mine
Alvord Mine
Cave Canyon Iron Deposit
Afton Magnesite Deposit
Afton Flourspar Deposit
Waterloo Mine
Calico-Odessa Group
Zenda Gold Mng Co
Total Wreck Mine
Shaherald Mining Co
Horner Bentonite Deposit
Bartle Hansen Deposit
Orange Blossom Ext Mine
Hercules Group
Winifred Group
Camp Rock Placer
Sidewinder Mine
Ozark Mine (Big Ten)
Golden State Cement Plant
Southwestern Portland Cement Co.
Bessemer Mtn. Iron Deposit
Pacific Mines Corp (Bagdad-Chase Mine)
Cave Springs Mng Corp
Allison Garnet
War Eagle Mine
Emerson Mine
American Group
Arlington Mines (Black Hawk Mine)
Rose Mine
Gold Mtn Mine
Holcomb Valley Placer
Swartout Canyon Limestone Deposits
California Portland Cement Plant
Ivanhoe Mine
Brooklyn & Los Angeles
Exchequer Mine
Supply Mine
American Eagle Mine
Tuscarora Mine
Mountain King Group
Lucky Jim Mine
Oro Plata Mine
Desert Mercury Group
Gold Reef Mine
Clipper Mtn Mine
Camp Castle Mine (Great Go & Bell)
Lena Louise Garnet
Iron Hat Group
Ship Mtn Iron Mine
Perseverance Mine
Providence Mine
Bonanza King Mine
Vulcan Group
Pilot Mine
Hidden Hill Mine
Mable Group
Columbia Mine
Francis Mine
Barrett Mine
Gold King Mine
Death Valley Mines
Tungsten King
Morning Star Mine
Standard Mine
Vanderbilt Mine
Sagamore Mine
Giant Ledge Mine
Gold Chief Mine
California Gold & Copper Mine
Vanadium King Mine
Piute Mine
Josie K Mine
Asbestos & Marble Mc Antire Deposit
Turquoise Mine
Pacific Coast Talc Deposit
Foster Mine
Carbonate King Mine
Colosseum Mine
Mohawk Mine
Mojave Tungsten Group
Desert Antimony Mine
New Trail Mine
Magnesite
Owls Head Mine
Myrick Gem Mine
Saratoga Springs Salt Gypsum Talc Celestite
Avawatz Salt & Gypsum Co Deposit
Goldstone Mine
Belmont Mine
California Rand Silver Mine
Atolia Mining Co
Saline Products
Calif Rock Salt Co
BRISTOL DRY LAKE
Danby Dry Lake

Two national highways traverse the county from east to west and many excellent state and county roads have been constructed in various parts of the county, greatly facilitating transportation and thus stimulating development of its natural resources.

Mineral Resources.

The mineral production from San Bernardino County is shown in the table printed herewith.

Prior to 1894 statistics on the production of gold and silver only are available. The recorded production through 1930 shows the imposing total of $200,640,397. Of this total perhaps $140,000,000 has been produced from the desert portion of the county. It is divided among 25 different substances, giving San Bernardino County a greater diversity of mineral wealth than any other county in the state.

The production of silver in the county was greatly augmented by the discovery of a rich deposit at Randsburg in 1919. This is known as the California Rand Mine and its total production has amounted to approximately $16,000,000, being for several years the largest single producer in the United States.

Another development in connection with silver mining in the county is the revived activity in the Calico District. Here the Silver King and Oriental properties have been taken over by the Zenda Mining Company and their development has disclosed new orebodies which may again put this old camp on a production basis. Encouraging results obtained by this company have been responsible for the reopening of the Odessa and Total Wreck mines. The mines of Calico District have a production record of over $10,000,000 in silver.

There is also a renewal of activity in the Virginia Dale District. Development work on the Virginia Dale Mine is now under way and much interest is being shown in other properties in this area. The development of an adequate water supply would no doubt result in a considerable production of gold from this district.

Improvement in the price of tungsten has led to the reopening of the mines at Atolia by the Atolia Mining Company. Two concentrators have been erected, having a combined capacity of approximately 900 tons daily. The 750-ton plant operates on gravel from the 'Spud Patch' at the southeast end of the tungsten area, while the 150-ton plant is treating ores from the Union Mine and various dumps scattered over the property.

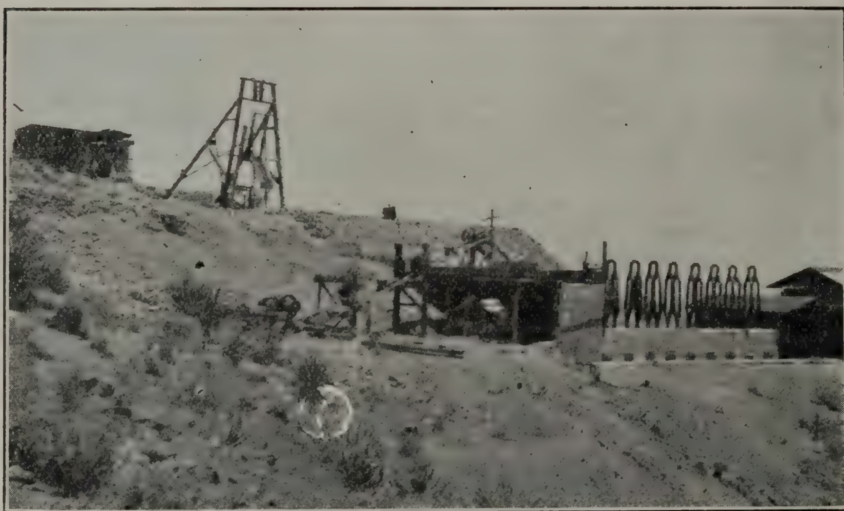
Two large plants on Searles Lake have been in continuous operation extracting potash, borax and soda from the brines of the lake. The American Potash and Chemical Corporation's plant at Trona produced 138,291 tons of potash and borax salts during 1928. The net operating profit for the year amounted to $1,556,541. The corporation is producing and marketing today 25 per cent of all the potash used in America and about one-third of the borax used in the world. It is stated that the corporation plans to double the capacity of the present plant during the year 1930.

In the following report on the mineral resources of the county, the metals are taken up in alphabetical order and the mines discussed in like manner, no segregation into the various mining districts being made.

Descriptions of the nonmetallic deposits follow and are arranged in the same manner.

On the accompanying map are shown the locations of the various mines and mineral deposits.

San Bernardino for several years has led all other counties in the State in point of variety of minerals, producing commercially during 1930 a total of 22 different substances, the following being included among its resources: Asbestos, barytes, borax, cement, clay, copper, gems, gold, granite, gypsum, iron, lead, limestone, manganese, marble, mineral paint, mineral water, nitre potash, salt, soapstone, soda, strontium, talc, tungsten, vanadium and zinc.



Shaft and furnace. Desert Antimony Mine, San Bernardino County.

ANTIMONY

Only a few tons of this metal have been produced in the county. Due to the unstable market and inability to compete with the Chinese products there has been little incentive to prospect for this substance.

Desert Antimony Mine. The property is situated in the Clark Mountain District, about 12 miles southwest of Roach, Nevada, a station on the Union Pacific Railroad. Elevation 5000 feet. Owner, J. J. Wade, Nipton, California. The property was operated under lease during 1927 and 1928 by *Triangle Mining Company* of Los Angeles. This company shipped 18 tons of ore, with metallic content of 40.3% antimony. Holdings consist of 3 claims: Desert Antimony, Desert Antimony Extension and Hongkong, totaling 60 acres.

The country rock is granite. Three parallel veins occur in the granite, their strike being N. 20° E.; dips vary from 75 degrees west to vertical. Width of veins vary from 2 to 4 feet. These veins are about 50 feet apart and most of the development work has been confined to the west vein. The ore so far developed occurs on the footwall, and the high-grade ore has a width of 12 inches to 2 feet. It is reported that ore mined carried from 15 to 20% antimony and was sorted to carry from 40 to 60% antimony. The ore is in the form of stibnite (Sb_2S_3).

Development: On the east vein, a tunnel has been driven west 30 feet to the vein, at which point a winze has been sunk to a depth of 30 feet. From the bottom of the winze a drift has been run 40 feet on the vein. This work has exposed a vein four feet in width with two feet of ore on footwall. West vein: On this vein a shaft has been sunk to a depth of 100 feet. At a depth of 50 feet there is a drift north 100 feet and south 40 feet. The vein material exposed in these workings consists of quartz, calcite and barite, mineralized with stibnite. In the north drift the vein has been stoped for a length of 80 feet to the surface. The ore extracted from this stope is reported to have carried from 30% to 50% antimony. In the bottom of the shaft there is 6 inches of high-grade ore. About 300 feet south of the shaft and 100 feet vertically below the collar of the shaft, a tunnel has been driven south 150 feet on the west vein. The middle vein has been developed by a number of open cuts for a distance of 1000 feet along its outcrop.

Mine equipment consists of 12-h.p. Western gas-engine hoist. Reduction equipment consists of one 10-ton furnace. Idle.

COPPER

The total value of copper produced in San Bernardino County through the year 1930 is $2,400,283.

Although copper is widely distributed throughout the mountain ranges of the desert area of the county, the annual production since 1918 has been small due largely to the unsettled market conditions and low prices prevailing.

The districts which have produced the largest tonnage of copper ores in the past are: Ivanpah, Ibex, Old Dad Mountain, Signal, Silver Mountain and Whipple. The largest single producers have been the Copper World Mine in the Ivanpah District and the Pacific Mines Corporation properties, seven miles south of Ludlow. Both of these properties operated until the latter part of 1918. Some interest is now being shown in the possible development of deposits in the Ord Mountain area.

Allured Copper Mine, consisting of 9 claims, is situated 12 miles northeast of Cima and immediately south of the New Trail Mine. Elevation 4200 feet. Owner, M. E. Allured, Jackson, Amador County, California.

A series of copper-bearing veins having a north-south strike occur in the limestone. The copper is in both the carbonate and sulphide form. Shipments made in the past are reported to have carried 8% to 20% copper.

Development consists of two shafts each 125 feet deep. Idle.

Bibl: State Mineralogist's Report XVIII, p. 611.

Amazon Mines consists of 6 claims in the Silver Mountain District, 6 miles east of Oro Grande. Owners, F. H. Cline et al., Oro Grande, California.

Oxides of copper occur in a contact vein between limestone and diorite. Development consists of two shafts 265 and 175 feet deep, respectively, and several tunnels. Shipments aggregating 300 tons were made several years ago. Idle.

Bibl: State Mineralogist's Reports XI, p. 363; XII, p. 69; XIII, p. 60; XV, p. 784.

American Eagle Group. It consists of 19 claims in the Whipple Mountain Mining District, in Sec. 32, T. 3 N., R. 4 E., S. B. M., 13 miles north of Vidal, the shipping point. Owner, *American Eagle Gold and Copper Company.*

The property was developed by 130-foot shaft and some drifts said to have exposed a large body of low-grade sulphide ore, varying up to 10% copper and from $2 to $21 in gold. The values are erratic and it is a highly siliceous ore. A shipment which assayed 6.35% copper, carrying 65 to 75% silica was so heavily penalized on this account that the shippers received no returns. Idle.

Bibl: State Mineralogist's Report XV, p. 784; Bull. No. 50, p. 337.

Bagdad-Chase Mine. (See under Pacific Mines Corporation.)

Big Butte Mine. It is in the Ibex District, 6 miles west of Needles. Elevation 1100 feet. Owner, K. K. Horan, Needles, California.

The ore contains gold, silver and copper. Development consists of 125-foot shaft and numerous short tunnels and open cuts. One car load was shipped to the Needles smelter in 1913. Idle.

Bibl: State Mineralogist's Report XV, p. 785.

Black Diamond Mine. It is in the Silver Mountain District, 8 miles east of Oro Grande. Owner, Joseph Scheerer Estate, Victorville, California.

Gold, silver and copper occur in a vein along the contact of a porphyrite dike and granite. A shaft 150 feet deep and several small cuts comprise the development work. Idle.

Bibl: State Mineralogist's Report XV, p. 785.

Black Metal Mine, consisting of 3 claims, is described as being 50 miles southeast of Needles, about 3 miles west of the Colorado River. Owner, George B. Parks, Barstow, California.

Development consists of tunnels 75 feet, 40 feet and 10 feet, respectively. Ore is chrysocolla and horn silver. Idle.

Bibl: State Mineralogist's Reports, XII, p. 376; XIII, p.606.

Black Mountain Mining Company owned 96 claims in T. 10 N., R. 21 E., 9½ miles west of Needles. Nick Johriess of Needles was president of the company. Idle.

Bibl: State Mineralogist's Report XV, p. 785.

Bumper Group, consisting of 6 claims, is 12 miles south of Needles. Elevation 1200 feet. Owners, E. H. and H. A. Norton, Needles, California.

The ore is said to contain malachite and azurite. Development consists of 22-foot shaft and connecting 65-foot adit. Idle.

Bibl: State Mineralogist's Report XV, p. 785.

Calarivada Mine, consisting of 2 claims, is located in the Clark Mountain District, in T. 18 N., R. 13 E., S. B. M., 23 miles west of Goodsprings, Nevada. Elevation 5000 feet. Owner, *Colosseum Mines Corporation.*

Copper ore occurs in the bedding planes along a northwest-southeast fracture in limestone. Dip is 40° E. The vein is from 2 to 4 feet wide, carrying copper oxides and chlorides of silver. Shipments are reported to have shown 10% copper and 15 ounces of silver.

Developed by a vertical shaft 200 feet deep, with 200 feet of drifts on the 100-foot and 200-foot levels. Idle.

A northwest-southeast vein in limestone from 2 feet to 4 feet wide, carries azurite, malachite, silver chlorides and some gold values in a quartz and silicified limestone gangue. Developed by a 200-foot vertical shaft with 200 feet of drifting on the 100-foot and 200-foot levels.

Equipment consists of 12-h.p. gasoline hoist. Idle.

Bibl: State Mineralogist's Report XX, p. 93.

California Gold Copper Company's mine consists of 9 patented claims in the Signal District, 9 miles north of Goffs. Elevation 3700 feet.

The property was equipped with electrolytic copper and 160-ton cyanide plants. Idle for years.

Bibl: State Mineralogist's Report XV, p. 785.

Camp Vera Group is in the Morrow District, 25 miles north of Barstow. Idle.

Bibl: State Mineralogist's Report XV, p. 785; Bull. 50, p. 334.

Claw Hammer Group consists of 4 claims in the Belleville Mining District, in the Ord Mountains, 6 miles southeast of Daggett. Owner, Jens Youngreen of Los Angeles.

Mineralization consists of chalcocite and malachite, occurring along fractures in a quartz monzonite near its contact with rhyolite. Strike of this belt is NE.-SW., dip 70° to the east. Width varies from 4 feet to 12 feet. Development consists of 30-foot shaft. Idle.

Columbia Mine. (See under Silver.)

Copper Basin Consolidated Mines Company's property, consisting of 9 claims, is in the Monumental Mining District, about 15 miles north of Parker, Arizona. Elevation 1000 feet above sea level.

Here too well-defined zones of mineralization occur in quartz porphyry. The strike is north-south, dip from vertical to 45° east. One of these zones has a width of from 5 feet to 40 feet and is traceable on the surface for about 2000 feet.

Mineralization to a depth of about 100 feet consists of copper carbonates, with some oxides.

The development work consists of open cuts, tunnels and shallow shafts. One shaft is 100 feet deep and shows an 8-foot vein assaying 5% copper. The bottom is in the sulphide zone, the ore consisting of chalcopyrite, pyrite and bornite. Some 600 feet from this shaft, an 80-foot shaft has been sunk on another vein. In the bottom this shaft appears to be entering a sulphide zone. Idle.

Bibl: State Mineralogist's Reports XVIII, p. 308; XIV, pp. 99–100, q. v.

Copper Bell Group, consisting of 8 claims, is in the Monumental District, 12 miles northwest of Drennan, a station on The Atchison, Topeka and Santa Fe Railroad.

The ore, carrying values in copper, gold and silver, occurs in quartz veins in granite. Idle.

Bibl: State Mineralogist's Report XVII, p. 339.

Copper Commander Group consists of 4 claims in the Clark Mountain, 22 miles north of Cima, in T. 16 N., R. 13 E., S. B. M., and adjoins the Copper World Mine on the northwest. Elevation 5500 feet. Owner, Mike Conway, Cima, California.

Ivanpah Copper Company's smelter. Valley Wells, San Bernardino County.

Copper World Mine. Ivanpah Copper Company, Clark Mountain District, San Bernardino County.

The ore on this property occurs in a broad mineralized zone at the contact of granitic porphyry with limestone, the porphyry being intrusive into hard, gray-colored limestone. The copper ores occur throughout the porphyry for a considerable distance from the contacts. In the mineralized zone, which is about 200 feet wide and has a general north-

west strike, veinlets of copper oxide ore occur. The ore is low grade, said to average about 4% copper.

Development consists of a tunnel driven southeast on the contact a distance of 140 feet, also a number of short tunnels and open cuts, all of which expose some ore. Idle.

Bibl: State Mineralogist's Report XX, p. 93.

Copper World Mine. (Tip Top Mine. See under Gold.)

Copper World Mine is located in Clark Mountain, Clark Mining District, T. 16 N., R. 13 E., S. B. M., 20 miles northwest of Ivanpah, a station on the Union Pacific Railroad. The property, consisting of 4 claims, lies at an elevation of 5180 feet. Owner, *Ivanpah Copper Company;* Dan Murphy, president; Dr. L. D. Godshall, general manager, 722 South Oxford, Los Angeles.

The property was operated by present owners from 1916 through the early part of 1919.

The mineralized zone which, in places, has a width of 200 feet, occurs at the contact of limestone and porphyry.

The property is developed by several thousand feet of underground workings, driven from three tunnel levels. The ore was smelted at Valley Wells, 5 miles southwest of the mine, in a 100-ton blast furnace.

For more detailed description see Seventeenth Report, p. 339. Idle.

Bibl: State Mineralogist's Reports XIII, p. 61; XV, p. 786; XVII, pp. 339–340. Bull. 50, pp. 326–328.

Confidence Copper Mine is in Sec. 5, T. 11 N., R. 14 E., S. B. M., in the Kelso Mining District, 4 miles southeast of Ames, a station on the Union Pacific Railroad. Holdings consist of 4 mining claims on the southwest slope of the Providence Mountains, at an elevation of 4000 feet. Owner, Confidence Copper Mining Company; Edward Bluett, secretary, Los Angeles.

The mineralization, consisting of chalcopyrite, pyrite, wolframite and gold, occurs in two true fissure veins, which have been formed on the contact of granite with a porphyritic rock, strike is east-west, dip 65° to the south. These veins are known as the Confidence and Francis. Vein filling is quartz and mineralized granite.

Development work consists of 100-foot shaft sunk on a 65° inclination and a number of shallow shafts and open cuts. Idle.

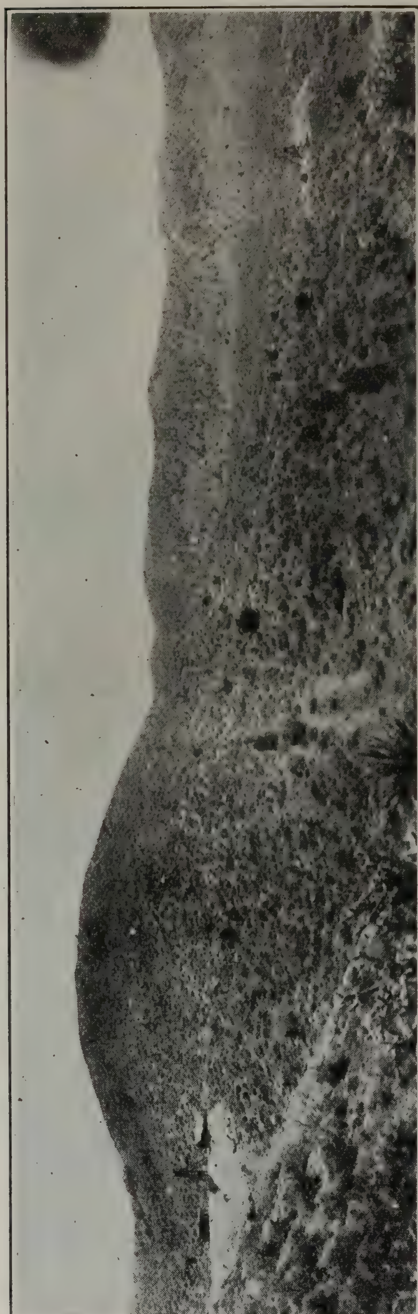
Bibl: State Mineralogist's Report XVII, p. 340.

D. and W. (*Dayton and Wilber*) *Mine* is in the Whipple Mountain District, 13 miles north of Vidal. It adjoins the American Eagle Group. Elevation 1800 feet. Owner, D. and W. Mining Company. Former address, 808 San Fernando Building, Los Angeles; Joseph Simon, secretary.

The ore containing malachite, azurite and gold occurs in a porphyritic dike in diorite. Property was formerly equipped with a 50-ton mill. Idle.

Bibl: State Mineralogist's Report XV, p. 786; Bull. 50, p. 327.

Desert Butte Group is 40 miles southeast of Amboy and 3½ miles south of Kilbeck. Owners, George B. Parks and A. J. Crowley, Barstow, California.



Cuyamaca and Woods shafts. Francis Copper Mine, Kelso Mining District.

Some shipments of complex ore, containing copper, gold, silver, lead and zinc, were made to Selby smelter in 1914. Idle.

Bibl: State Mineralogist's Report XV, p. 786.

Desert Queen Copper Mines Company. It was reported that this company was operating a property in the northern part of the county and that shipments of ore were made to the International smelter in Utah. No further information available. Presumably idle.

Emperor Mine. (See under Lead-Silver.)

Foster Mine (*Glory Group of Mines*). This property, consisting of 22 claims, is situated in T. 17 N., R. 11 E., S. B. M., in the Shadow Mountain District; 25 miles east of Silver Lake. Owner, Foster Mines Company; E. D. Foster, president and general manager, Los Angeles.

A series of parallel veins in porphyry and schist carry values in copper, gold and silver. Three shafts have been sunk on different veins; greatest depth 125 feet.

A new company has been formed to operate this property known as the *Glory Mines, Ltd.*, 515 Consolidated Building, Los Angeles. E. D. Foster is consulting engineer in charge of operations.

Bibl: State Mineralogist's Report XVII, p. 341.

Francis Copper Mine, comprising 8 claims, is located in the Kelso District, on the southwest slope of the Providence Mountains, 4 miles southeast of Ames, a station on the Union Pacific Railroad. Elevation 4350 feet. Owner, Francis Copper Mining Company; C. Colcock Jones, president; C. H. McWilliams, secretary, 1014 Quinby Building, Los Angeles.

A gneissic-schistose formation of pre-Cambrian age has been intruded by dikes of quartz-porphyry and diorite, with the creation of a vein-dike system and replacement area coincident with a northeast-southwest fissuring. This has resulted in one major vein, on which the present work has been done, and a number of parallel and intersecting veins, in a width of 1200 feet, the length of the zone being 4500 feet.

There are three principal, parallel porphyritic intrusions and accompanying vein-dikes. The Western Star, which is the most northerly one, is a quartz-porphyry dike up to 70 feet in width.

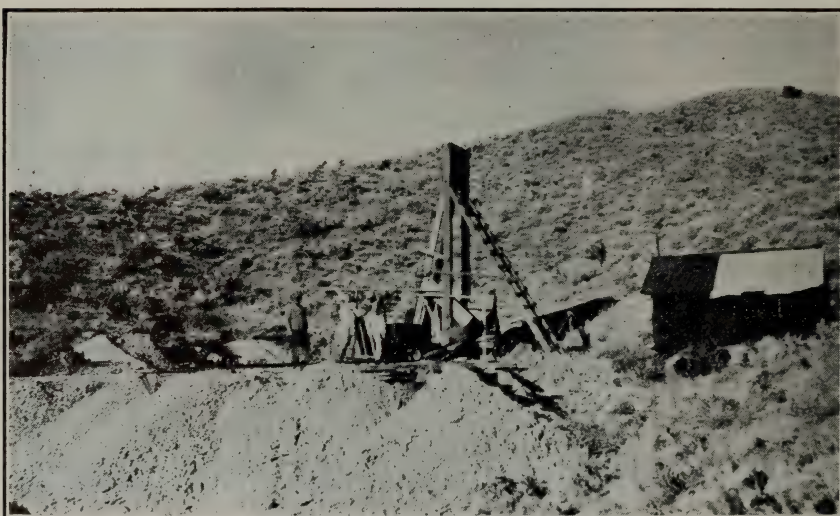
The Cuyamaca-Woods dike No. 3 outcrop can be traced for more than 2500 feet. It has been developed by two shafts. The Francis shaft, being 140 feet deep, has been further developed by some 600 feet of drifts and crosscuts. The Woods No. 2 shaft has been sunk on the same ledge some 1500 feet west of the Cuyamaca, to a depth of 40 feet. Here the quartz outcrop is from 6 to 30 feet wide and the shaft has disclosed 6 feet of quartz. Values in this vein are more or less oxidized and leached, but there is an 18-inch streak in the center which carries copper-silver values in the sulphide form.

The outcrop of the Cuyamaca vein, in which the principal development work to date has been done, is from 10 to 50 feet wide and may be traced for a distance of 2500 feet. The ore is silver, copper, lead and zinc sulphides in a quartz gangue. The values are reported to be as follows: Silver 2 to 25 ounces, copper 2% to 12%, lead 2% to 6%, and zinc 4% to 20%. The Francis shaft on the Cuyamaca claim is 140 feet

deep and is connected on the 70-foot level with the bottom of another shaft by a drift which is 160 feet long. A total of 600 feet of drifting and crosscutting has been done here. The vein varies from 3 to 4 feet in width and shipments are reported to have given smelter returns of 12.3 ounces silver and 2.35% copper, no payment being made for lead or zinc.

In 1917–18 shipments from the Cuyamaca shaft aggregating 307 tons were made to the Valley Wells smelter. Of these shipments the last 5 cars averaged 10.2 ounces silver and 2.19% copper, with no payment for lead or zinc, the average of the 307 tons being 7.9 ounces silver and 1.7% copper.

The Godshall shaft, 450 feet southwest of the Francis shaft, has been sunk to a depth of 100 feet on the hanging wall of the Cuyamaca vein, which dips 70° to the north. This work exposed a vein 6 feet in width, with reported assays from the material on the dump of 12.2 ounces of silver and 1.2% copper.



Headframe and hoist. Francis Copper Mine, Kelso Mining District, Providence Range of Mountains, San Bernardino County.

Average value of ore from the 70- and 136-foot levels of the Francis shaft are reported as follows:

70-foot level—15.7 oz. silver, 9.45% copper.

136-foot level—2.72 oz. silver, 3.08% copper, 16.20% zinc.

The above-mentioned values are across widths of from 3 to 4 feet.

Equipment consists of 6-h.p. gas engine, hoist and gallows frame at the Francis shaft, together with bunk house and boarding house. Idle.

Bibl: State Mineralogist's Report XVII, p. 341.

Giant Ledge Gold and Copper Mine is in the New York Mountains, 10 miles northwest of Ledge, a station on the Ivanpah branch of the Santa Fe Railroad. Elevation 5700 feet. Presumably idle for many years.

Bibl: State Mineralogist's Report XV, p. 786; Bull. 50, p. 333.

Halloran Springs Mine, comprising 4 claims, is situated in an unknown mining district, in T. 14 N., R. 10 E., S. B. M., 15 miles southeast of Silver Lake Station, on the Tonopah and Tidewater Railroad. Elevation 2500 feet. Owners, Charles A. Kellogg and C. V. Welch, Los Angeles.

The country rock consists of granite and andesite. The ore occurs along a shear zone in an andesitic porphyry. This zone is from 20 to 50 feet wide. Its strike is NW.-SE. and the dip is vertical. The mineralization consists of azurite, malachite, silver chlorides and bromides, with some gold values.

Development consists of some shallow shafts, not exceeding 30 feet in depth and an open cut. Idle.

Hercules Group in the Hikorum (Old Dad Mountain) District, is 9 miles north of Bagdad. Elevation 3200 feet. Owner, Robert Andrews, Bagdad, California.

Veins occur in a fine-grained quartz porphyry and carry carbonates of copper with some gold values. Developed by a 42-foot shaft and several open cuts. Reported to have shipped 1400 tons of ore, varying from $6 to $8 in value. Idle.

Bibl: State Mineralogist's Report XV, pp. 786–787.

Hermit Mine, formerly known as Blue Jacket. (See under Silver.)

Hidden Hill Mine. (See under Gold.)

Hidden Treasure Copper Mine is in the Signal District, 12 miles east of Goffs. Elevation 2450 feet. Owners, A. L. Morehead and W. F. Chausse, Goffs, California.

Ore occurs on contact of granite and schist. Strike N. 40° W., dip 45° SE. Developed by a series of prospect holes and trenches and one shaft 160 feet deep. Idle.

Bibl: State Mineralogist's Report XVII, p. 341.

Home Mine is in the Hikorum (Old Dad Mountain) District, 12 miles north of Bagdad. Elevation 2960 feet. Owners, L. V. Root and Joseph Luxon, Needles, California. Idle.

Bibl: State Mineralogist's Report XV, p. 787.

Hoosier and Missouri Groups are in Sec. 28, T. 10 N., R. 3 W., S. B. M., 12 miles northwest of Barstow. Owners, J. W. Foglesong and E. Troutman, Barstow, California.

Ore carrying gold, silver, copper and lead occurs in a quartz ledge, said to vary up to 15 feet in width, on a contact of rhyolite and granite.

Development consists of a 90-foot shaft and 300 feet of drifts. Idle.

Bibl: State Mineralogist's Report XV, p. 787.

Ivanpah Mine is in the Ivanpah District, about 27 miles north of Ivanpah, in T. 16 N., R. 15 E., S. B. M. Idle.

Bibl: Bull. 50, p. 330.

Ivanpah Mammoth Mine is in the Ivanpah Mountains, about 5 miles from Ivanpah, in T. 15 N., R. 14 E., S. B. M. Idle.

Bibl: Bull. 50, p. 330.

Jachon Mine is 12 miles north of Barstow and 6½ miles northeast of Williams Well. Elevation 4000 feet. Owner, R. M. Dillingham, Barstow.

Three fissure veins in granite, varying from 8 inches to 4 feet in width, carry oxidized ores of copper and gold. Strike NE.-SW. Development consists of 120-foot shaft sunk on 70° incline and 60 feet of drifts. Idle.

Juanita Group, in the Morrow District, adjoins the Juanita Mine. Idle for many years.

Bibl: Bull. 50, p. 335.

Juanita Mine is in the Morrow District, 26 miles east of Johannesburg. Idle.

Bibl: Bull. 50, p. 335.

Josie K. Mine is in the Ibex District, 6 miles west of Needles and 3 miles south of Hartoun. Idle.

Bibl: State Mineralogist's Report XV, p. 787.

Lake View Mine is in the Silver Lake District, 16 miles south of Silver Lake Station on the Tonopah and Tidewater Railroad.

The ore occurs on a contact of porphyry and limestone, and consists of chalcopyrite.

Developed by 50-foot shaft and 600 feet of tunnels. Idle.

Leastalk Gold and Copper Company is in the Barnwell District. Idle.

Bibl: State Mineralogist's Report XV, p. 787; Bull. 50, p. 330.

Leastalk Gold and Copper Mining Company has 12 claims in the Vanderbilt District. Idle.

Bibl: Bull. 50, p. 336.

L. and L. Group of Mines, comprising 17 claims, is located in the Ord Mountain District, in Sec. 17, T. 7 S., R. 3 E., S. B. M., 9 miles southeast of Newberry Springs. Owner, L. and L. Mining Company; O. A. Lau, president, Riverside, California.

Several roughly parallel veins occur in this property. On the Gigantic claim a shaft sunk to a depth of 50 feet on a 50° inclination follows a vein, the strike of which is NW.-SE., dip 50° SW. This quartz vein, 12 inches to 18 inches wide, contains malachite, azurite, bornite and chalcopyrite. The footwall is diorite and the hanging wall is monzonite. Reported values up to $15 gold and 9% copper. In the hill to the northwest of this shaft, a crosscut tunnel was driven 469 feet N. 70° E. and has about 200 feet to go before intercepting this vein.

Some 300 feet east of the shaft is auother quartz vein, strike N. 10° E., dip 75° W. It is 3 feet wide and the ore in the vein is from 12 inches to 18 inches wide.

Lucky Jim Mine, consisting of 5 claims, is in the Old Woman Mountains, T. 1 N., R. 21 E., S. B. M., about 20 miles north of Milligan, a station on the Parker cut-off of the Santa Fe Railway. Elevation about

2700 feet. Owner, E. J. Morath, 521 Walnut Street, Long Beach, California. Under lease to F. A. Crampton, on the property.

Quartz vein accompanies a porphyritic dike in granite. As is usual in this type of vein, the lenses are found on either wall of the dike and probably overlap. Strike is N. 65° W., dip about 85° N. The vein is reported to average 4 feet in width. The vein matter is a vitreous quartz. Minerals observed were chlorides and bromides of silver and chalcopyrite. Occurrences of argentite and ruby silver are reported, but none were seen. The principal values are in silver.

Shipments aggregating approximately $35,000 in value have been made since the opening of the mine in 1911. These shipments of selected ores are reported to have run from 200 to 400 ounces of silver, $3 to $4 gold, about 5% copper and 5% lead.

Principal development consists of 500 feet of crosscut tunnel driven north, which is connected with the surface by means of a 200-foot shaft. This shaft was the original opening and considerable work was done in it between the tunnel level and surface, which is now inaccessible. No doubt all ore above the tunnel has been stoped. On the tunnel level, a drift west has been driven about 200 feet and one east for a distance of 150 feet. A winze 85 feet deep was sunk at the intersection of the crosscut and drifts. At 150 feet west of the crosscut, a winze has been sunk to a depth of 35 feet and at about 165 feet west of the crosscut there is a 100-foot raise. As stoped the ore shoot appears to have been from 75 feet to 100 feet long.

Three men are employed sinking the west winze, which is now 35 feet deep, and a drift north has been started at the bottom.

Equipment consists of compressor, driven by tractor engine, drills, Little Tugger hoist at winze, blacksmith shop, and 3 cabins. A three-mile pipe line brings water to the camp from a spring.

The present operator is directing his efforts towards the development of sufficient ore to warrant the erection of a mill.

Mohawk Mine. (Ivanpah Copper Co. See under Lead-Silver.)

New Trail Mine, comprising 28 claims, is located on the east slope of the Ivanpah range of mountains, 11 miles northwest of Cima, a station on the Union Pacific Railroad. Elevation 5000 feet. Owner, New Trail Mining Company; J. F. Kent, president, Box 867, Riverside, California.

Here a bed of limestone some 2500 feet in thickness, strike N. 30° W., dip 45° NE., lying between granite walls, has been intruded by dikes of monzonite. This limestone has been faulted along a northeast-southwest line, with a throw of several hundred feet.

A dike, consisting largely of garnet and epidote, strike N. 40° E., dip 80° NW., cuts across the bedding planes of the limestone. A two-compartment shaft was started on this dike. To a depth of 100 feet the shaft followed the dike, but from the 100 to the 200-foot level the shaft is in the hanging wall of the dike. On the 100-foot level at a distance of 20 feet southwest of the shaft, the dike is faulted to the northwest, showing a displacement of 20 feet. The ore which formed in this fracture and for a few feet in the bedding planes on each side has been stoped to the surface. The dip of the fracture is 50° SW. At 150 feet southwest of the shaft, a high-grade ore consisting of

bornite and chalcopyrite was encountered on the northwest side of the dike. The fracture along which this ore has formed crosses the dike at a distance of 170 feet from the shaft. At 235 feet from the shaft there is a third, parallel cross-fracture. The drift continues for a total distance of 400 feet southwest of the shaft. There is also a drift northeast from the shaft, 120 feet. No ore was encountered in this drift.

On the 200-foot, which is the bottom level, at 125 feet southwest of the shaft, there is a NW.-SE. cross-fracture, which is mineralized. A drift has been driven northwest for a distance of 35 feet on this ore. At 30 feet from the main drift, a winze has been put down to a depth of 50 feet. There is also a small stope above the level at this point. Irregular bunches of chalcopyrite and bornite were found here and two cars of this ore were shipped. It is reported that returns from these shipments showed $5 in gold and from 8% to 15% copper. The drifting on this level followed the dike in a southwesterly direction for a distance of 440 feet. In the face of these workings, a tongue of serpentine was encountered. A 50-foot drift was also driven northeast from the shaft.

About 3000 feet south of the shaft, a N.-S. fracture, dip 50° W., has been worked to a depth of 80 feet and some 200 feet east of this shaft. Here, a zone some 40 feet in width is copper stained and the mineralization consists of copper carbonates and oxides.

On the south end of the claims there is a series of fractures, the strike varying from N. 60° E. to N. 40° W. All of these show mineralization along the intersections.

Equipment consists of 15-h.p. Fairbanks-Morse gas engine hoist and 300-cu. ft. Chicago pneumatic compressor.

Present explorations are with a churn drill. Two men employed.

New York Mines. (See Sagamore Mine.)

Orange Blossom Mining and Milling Company, in the Hikorum (Old Dad Mountain) District, 9 miles north of Bagdad, has been idle for several years.

Bibl: State Mineralogist's Report XV, p. 788; Bull. 50, pp. 338–339.

Orange Blossom Extension Mine adjoins the Orange Blossom property on the north. A mill was erected here, but only ran a short time. Idle.

Bibl: State Mineralogist's Report XV, p. 789; Bull. 50, p. 340.

Ord Mountain Mine (formerly known as the Osborn Group). This property, consisting of 8 patented claims and 20 claims held by location, is in the Ord Mountain District, 14 miles southeast of Daggett. Elevation ranges from 4000 to 5500 feet. Owner, Frank A. Werner, 2029 West Washington Street, Los Angeles. Under option to *Ord Copper Company, Ltd.*, Courthouse, Las Vegas, Nevada. J. L. Carder, president and general manager; George B. Hayden, treasurer, 225–227 I. W. Hellman Building, Los Angeles.

The patented claims are the Coupon, Tehachapi, Brilliant, Central, Rio Vista, Modesto, Last Chance and Josephine. They are on the north

side of Ord Mountain, on steep slopes which often terminate in precipitous cliffs at the top of the spurs.

The principal rock exposures are an ancient andesitic flow and monzonite. The andesite lies in a north-south belt from 2000 to 3000 feet wide. On both the east and west sides it is in contact with the monzonite. A series of roughly parallel veins occur in the andesite. The strike of these veins varies from about N. 15° E. to N. 15° W., dip 50 to 70° to the east. The wall rock adjacent to the veins is distinctly schistose, evidently from shearing stresses developed where the fissures were made. There are four east-west faults crossing the property which displace the veins from 100 to 400 feet. The width of the veins varies from 4 to 20 feet. The vein filling consists of brecciated wall rock recemented with quartz. The mineralization for approximately 125 feet in depth consists of copper carbonates and free gold. Below this depth, the primary sulphides, chalcopyrite and bornite, carrying gold, are the principal minerals. This belt is traceable, on surface, for a distance of approximately 2½ miles.

Considerable development work, scattered over a period of some thirty years, has been done on the property. The Brilliant shaft was sunk on an inclination of 70°, a distance of 200 feet. On the first level, approximately 100 feet from the surface, there is a drift south 25 feet. On the second level, which is at a depth of 182 feet, there is a drift south 40 feet, also a crosscut from the shaft, east 22 feet, and a drift from the end of this crosscut about 45 feet south. There is also a drift north from the shaft 45 feet. It is reported that the crosscut is all in ore, averaging $4 in gold and 3% copper, largely in the carbonate form.

On the Belgium claim, at an elevation of 4000 feet, a main haulage tunnel has been started. It is being driven due south. It is intended to continue this tunnel for approximately 6800 feet, which will bring it under the present workings on the Rio Vista, 700 feet below the lower Rio Vista tunnel and 1100 feet below the surface. It is now in 200 feet and it is believed that it will be on the vein for its entire length. There is another tunnel on the Belgium claim, the portal of which is adjacent to the portal of the main haulage tunnel. It was driven in a southwesterly direction, a distance of 480 feet. At 140 feet from the portal, there is a winze 160 feet deep. Further sinking in this winze is now in progress.

On the Josephine claim is a tunnel driven southwesterly a distance of 475 feet. It is reported that this tunnel shows good ore for a width of 18 feet. Some 200 feet southwest of the face of the tunnel there is an 80-foot shaft.

On the Coupon claim there is a crosscut tunnel west 170 feet. At 150 feet from the portal is a drift south 40 feet and 200-foot crosscut west from the face of the drift.

On the Rio Vista there are two tunnels. These are approximately 125 feet (vertically) apart, the upper one being about 300 feet below the top of the mountain. The lower tunnel is a crosscut east 770 feet. At 700 feet from the portal there is a drift south 437 feet and north 110 feet. The upper tunnel is a crosscut east about 250 feet. Drifts have been driven north and south. The south drift is caved at 150 feet from the crosscut and the north drift is now open for only a few

feet. Just north of the crosscut is a raise to the surface. Some stoping has been done here in the past but is not now accessible.

Practically all of the drifts are on veins which carry values both in gold and copper. No information regarding real averages are available, although it is reported there is much ore exposed which carries from \$3 to \$4 and 2% to 3% copper.

Eight men are employed driving haulage tunnel and sinking the winze which is eventually to be a working shaft 1000 feet deep.

Bibl: State Mineralogist's Reports X, p. 528; XII, p. 234; XIII, p. 326; XV, p. 789. Bull. 50, p. 336.

Ozark Mine, also known as The Big Ten. (See under Gold.)

Pacific Mines Corporation. (Bagdad-Chase and Roosevelt Mines.) This property, which is 7 miles south of Ludlow, comprises 17 patented claims, totaling 340 acres. Principal owners, John H. Hobbs and Mrs. Edith George, Glendora, California.

It was operated by the above company, which had its principal office at 120 Broadway, New York City; J. N. Beckley, president; J. H. Hobbs, secretary; Frank W. Royer, of Los Angeles, consulting engineer.

There is a railroad from Ludlow to the mine.

The ore is deposited in an igneous breccia on a contact of monzonite and rhyolite. The brecciated material, which is the result of faulting, consists of both rhyolite and monzonite fragments cemented with a highly silicious material. The strike of this zone is east and west and it dips 25° to 30° to the north. Its average width is from 8 to 15 feet. It has been proved on the surface along its strike for 2000 feet. The footwall is monzonite with a rhyolite hanging wall. The orebody has been faulted by a series of faults which strike north and south, with displacements varying from 100 to 240 feet.

The ore is principally oxides of copper, some silicates and very finely divided gold. But little sulphides, if any, has been encountered. The gangue is very siliceous and is heavily stained with iron oxides.

When in operation this mine shipped many thousand tons of ore to the Clarkdale, Arizona, smelter. This ore is reported to have carried 0.27 ounces of gold, 5 ounces of silver and 1.5% copper.

Developments consist of vertical shaft 400 feet deep, incline shaft 450 feet on 30° incline, also shafts 200 feet, 140 feet and 120 feet deep, respectively. All of these shafts were sunk on the ore and several thousand feet of drifts and crosscuts were driven from them. Each shaft is equipped with a gasoline hoist. A 16-inch by 14-inch by 10-inch Sullivan, two-stage compressor supplies air for the drills.

Before operations were suspended a small, experimental flotation plant was erected. It is reported that tests in this plant showed a recovery of 90% of the gold, 40% of the silver and 95% of the copper.

It was estimated by various engineers that there is 150,000 tons of available ore yet remaining in the mine, the average copper content being 1.4% to 1.5% and from \$7 to \$8 gold per ton. It is also reported that there is a possibility of discovering the downward extension of these orebodies some 1500 to 2000 feet north of the present workings. In this case, the ores heretofore worked would represent the faulted portion of the original orebodies, this faulted zone having been moved south from 1500 to 2000 feet. Should this theory prove to be correct,

the discovery of a sulphide zone might lead to a long life of productiveness for this mine. Idle.

Bibl: State Mineralogist's Reports XV, p. 790; XVII, pp. 341–342.

Pauper's Dream and Quidunc Group, consisting of one and a fraction claims, is located on the southwest slope of the San Bernardino Mountains. It is in Sec. 4, T. 2 S., R. 1 W., S. B. M., about 5 miles northeast of Yucaipa. Elevation about 3500 feet. Owner, R. L. Brooks, Yucaipa, California.

Quartz vein 6 inches to 12 inches wide, associated with felsite dike in schist. Reported to carry values up to 4% copper and $4 to $12 in gold. Development consists of 30-foot shaft and opencuts.

One man employed on assessment work.

The Piper Group, consisting of 6 claims, is 1½ miles north of Barstow. Elevation 3000 feet.

Quartz vein carrying copper and gold occurs in schist.

The Price Group of 11 claims is located in T. 6 N., R. 2 W., S. B. M., 12 miles east of Victorville. Elevation 4200 feet. Owners, A. C. Price and Milton McNiellan, Long Beach, California.

A 3-foot to 5-foot vein, filled with highly copper-stained barite, occurs in an east-west fracture in limestone dip 80° to the south. There are two other veins, associated with epidote dikes in the limestone. They are parallel, strike N. 40° W., dip 75° NE.; width 3 feet and 4 feet, respectively. The vein filling is copper-stained barite.

Development consists of 35-foot shaft on the first vein; opencuts and a crosscut tunnel on the other two. Idle.

Rincon Mines Company has 28 claims in the Monumental Mining District, about 25 miles north of Parker, Arizona. The property is divided into five groups namely: Rincon Copper Group, 12 claims; The Rincon Placer Group, 2 claims; Hematite Gold Group, 4 claims; Klondike Group, 5 claims; Owl Group, 5 claims.

The Rincon Group millsite and mill are on the banks of the Colorado River. Property is now idle. For further information see

Bibl: State Mineralogist's Report XVII, pp. 308–309.

Rosalia Mining and Milling Company. (See under Gold.)

Silver Dome Mine. (See under Gold.)

Silver Lake. (See under Silver.)

Sagamore Mine (formerly *New York Mine*) is on the south slope of the New York Mountains about 10 miles west of Burdy and 6 miles south of Vanderbilt. Elevation 5800 feet. In New York Mining District. Owner, *Ivanpah Copper Company.*

This property, on which considerable work has been done in the past, has been idle for several years.

Bibl: State Mineralogist's Report XV, p. 790; Bull. 50, pp. 331, 332.

Standard Mine is located in the Ivanpah District, 15 miles north of Cima.

Some ore was shipped from this property several years ago but no work has been done in recent years.

Bibl: State Mineralogist's Report XV, p. 790; Bull. 50, p. 330.

Thelma and Mammoth Group in the Goldstone District, 33 miles north of Barstow.

Quartz veins in granite carry values in copper, gold and silver. Development consists of a series of prospect shafts 10 feet to 20 feet deep. Idle.

Three States Mine is in the Silver Lake District, 6 miles west of Silver Lake.

The ore is chalcopyrite which occurs along the contact of dioritic dikes with limestone. Idle.

Bibl: State Mineralogist's Report XV, p. 791.

Tuscarora Mine. It is located 7 miles northeast of Calzona, a station on the Parker cut-off of the Santa Fe Railroad.

The vein is 5 to 10 feet in width, occurring on contact between schist and diorite. The ore is said to average 2.5% copper with $10 to $20 in gold. Development consists of several shafts. Idle.

Bibl: State Mineralogist's Report XV, p. 791.

GOLD

Gold was first discovered in the San Bernardino range of mountains in May, 1860. The total recorded production through the year, 1930, amounted to $7,954,202. It is the most widely distributed metal of commercial importance in the county.

The auriferous veins of the county may be divided into two chief groups: Those of the San Bernardino range and those of the desert ranges. The veins of the San Bernardino range for the most part, occur on and near the north slope, which rises from the margin of the Mojave Desert.

The principal districts are: Bear Valley, Black Hawk, Holcomb Valley and Morongo.

The chief districts in which the desert veins occur are: Arrowhead, Dale, Goldstone, Gold Reef, Ivanpah, Ord, Oro Grande, Steadman, Twenty-nine Palms and Vanderbilt.

In April, 1926, some excitement resulted from the reported discovery of high-grade gold ores in Kramer Hills. Thousands of people from Los Angeles, San Bernardino and adjacent territory visited the district and hundreds of claims were located. Many shallow shafts were sunk but none of this work resulted in the development of a mine. The only systematic attempt to develop a producer in the district is described in the body of this report under the name of the Shaherald Mining Company.

The district is located in a low range of hills in the southern portion of T. 10 N., R. 6 and 7 W., S. B. M. It is 3 miles south and approximately 6 miles east of Kramer, a station on the Barstow-San Francisco line of Atchison, Topeka and Santa Fe Railroad and about 3 miles east of the road from San Bernardino to Randsburg. The axis of these hills has a general east-west direction. They rise some 400 to

500 feet above the floor of the valley to a maximum elevation of approximately 3000 feet.

The backbone of the range is probably granite, but on the north slope where the gold values are found, there are few exposures, the surface being covered with alluvial deposits. Due to the character of this alluvium, it is thought that the granite which shows on the south side of the hills, is flanked on the north by a wide body of pegmatite. This extends down the north slope to within some 250 feet, vertically, of the floor of the valley. At this point there is a schist belt which traverses the country in an east-west direction for a distance of some two miles. Its width varies from about 100 to 200 feet and it dips at a low angle to the south. In this schist belt, more or less closely associated with narrow dikes of volcanic rocks, are found the gold values. High-grade streaks and pockets have been encountered on the contact of the dikes and schist, while low-grade values seem to be disseminated through the schist, but close observation shows that they are between the laminations of the schist, and in joints which have been developed in the rock. These joints are approximately at right angles to the schistosity and are so close together that samples taken in crosscuts would appear to indicate uniformity distributed values in the rock itself. Such dissemination is present to the depths to which this area has been prospected. The gold is practically all free; very little sulphide showing in the ore. Vein filling consists of talc, quartz grains and crushed wall rock. Values are also found in a loosely cemented breccia which occurs along the contacts.

It is reported that this district is now being investigated for the purpose of determining whether this deposit may be handled profitably by steam shovel, the ore to be treated in a cyanide plant.

MINES

Altuma Mine. It is situated 15 miles east of Bear Valley and about 3 miles south of Rose Mine. Elevation, 8000 feet.

Bibl: State Mineralogist's Reports XII, p. 229; XIII, p. 319.

Alvord Mine. It is situated 23 miles northeast of Daggett and 6 miles north of Manix, a station on Union Pacific Railroad. Idle. Owner, Mr. McCormick, Yermo, California.

Bibl: State Mineralogist's Reports VIII, p. 499; XI, p. 359; XIII, p. 319.

Anaconda Mine. It is situated in the Twenty-nine Palms Mining District, about 55 miles northeast of Banning. Elevation 2850 feet. Owner, P. T. Sullivan, Twenty-nine Palms, California. Holdings comprise 4 claims.

Vein occurs in granite, strike N. 40° W., dip 73° E. The vein varies from 8 inches to 2 feet in width. Developments consist of two shafts, 100 feet and 185 feet deep. Production $10,000. Idle.

Bibl: State Mineralogist's Report XVII, pp. 344, 345.

Apex Mine is in the Oro Grande District, about 4 miles north of Oro Grande. It adjoins the Gold King on the west. Owner, Ed Merkle, Victorville, California.

Development consists of 300 to 400 feet of tunnels. The portal of tunnel has a door which was locked at the time of visit. Idle.

Arlington Mines (formerly known as *Black Hawk Mines*). This property comprises a group of 47 claims, known as the Black Hawk Group of Mines, situated in Secs. 5, 8, 9, 16 and 17, T. 3 N., R. 2 E., S. B. M., 35 miles southeast of Victorville, on the east slope of the San Bernardino range of mountains. Elevation 4200 feet to 6700

Opencut on Black Hawk lode. Blackhawk Canyon, San Bernardino County. Arlington Mining Corporation.

feet. Owner, Arlington Mining Corporation; Algeron Del Mar, president; Roy K. Voorhies, secretary. Offices, 740 South Broadway, Los Angeles. The property has been under active development by this company since 1922.

Geology: The geology of the Blackhawk Canyon area is described in detail by A. O. Woodford and T. F. Harries in a bulletin issued by the Department of Geological Sciences of the University of California, Vol. 17, No. 8. The formations that occur in the vicinity of Blackhawk Canyon are gneissoid granite overlain by white, gray or reddish metamorphic limestone, and a series of interbedded sandstone. The metamorphic limestone is almost pure calcite or pure dolomite or a mixture of the two. Along Blackhawk Canyon the limestone is in the form of a breccia. The brecciated limestone masses that have been exposed by this canyon are a part of the mountain range and stand in cliffs hundreds of feet high.

Ore occurrence: The ore consists of crushed limestone breccia slightly silicified, with red iron streaks running through the brecciated wall that gives it a pinkish or reddish color. The fragments range from one-quarter inch to 6 inches in diameter, the major portion being less than 3 inches. The fragments are slightly cemented together, stained red, being principally calcite, with some dolomite, and a few irregular grains of quartz. The footwall of the ore zone is granite

with a hanging wall made up of massive limestone. The Black Hawk lode which follows along Blackhawk Canyon strikes N. 20° E. and dips 5° to 20° to the S.W. This lode has been developed principally on the Cliff, Black Hawk and Senator Group of Claims.

The Arlington-Santa Fe lode strikes N. 80° E. and dips 5° to 20° SW. The crushed zone is at least 100 feet thick, with a gneiss footwall and a limestone hanging wall. In the Santa Fe Mine near the top of the crushed zone, the ore occurs as a dark red gouge which varies from 2 to 6 feet in thickness.

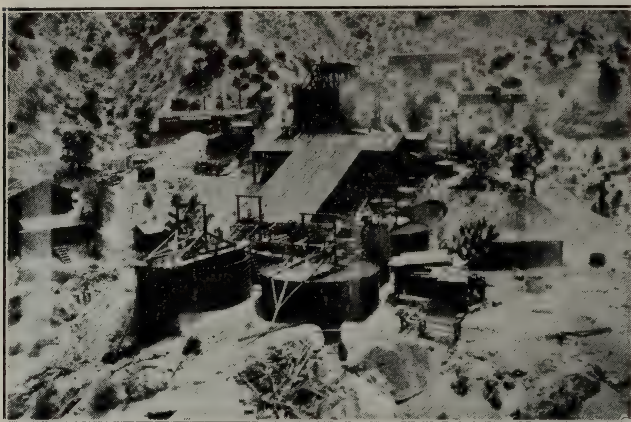
The gold occurs in the soft material that forms the filling between the crushed fragments and not in the coarse pieces of hard rock. The richest ore is found in the hematite streaks that occur at intervals throughout the crushed zone. The major portion of the gold values is concentrated in the fine materials. The ore is free-milling, oxidized gold ore.

Orebodies: At the extreme end of Blackhawk Canyon, at an elevation of 6100 feet, occur the orebodies of the Santa Fe-Arlington group. The lode is 4500 feet in length. The thickness of the orebody varies from 30 to 100 feet. The principal development work consists of 4 tunnels, from which about 2000 feet of crosscuts and drifts have been driven. Besides this development there are nine tunnels varying in length from 20 to 250 feet. Total amount of underground workings is 12,000 feet.

Black Hawk lode 300 feet thick. Cliff Mine in Blackhawk Canyon. Arlington Mining Corporation.

Estimated tonnage on Santa Fe-Arlington Group: East End Santa Fe: Orebody 110 feet thick, containing 550,000 tons, is said to have an average value of $2.30 per ton in gold. West End Santa Fe: In this area there are a series of five or more parallel veins, one of which is known as 'Calle de Oro Vein,' has been developed by tunnel and incline winze to a depth of 400 feet from surface. The ore extracted from this development work, about 2000 tons is reported to have had an

average value of $11 per ton in gold. On the fourth level this vein has a width of 12 feet. On the fifth level, the vein varies from 20 to 40 feet wide. About 40,000 tons of ore have been developed having an average value of $5 per ton. It is estimated that on the Santa Fe Claim the amount of probable ore developed amounts to about 600,000 tons, having an average value of $3 per ton.


Black Hawk Mill, Arlington Mining Corporation.

Cliff Mine area: The Cliff Mine which is located in Blackhawk Canyon has been developed by over 1200 feet of tunnel and raises, which have exposed a shattered orebody 75 feet thick. It is stated that on this claim there has been developed 350,000 tons of ore that has an average value of $1.75 per ton in gold. Overlying the Cliff orebody, there is 300 feet of shattered blue limestone that is stated will average 85 cents per ton in gold. Taking this deposit as a mass of ore, it is estimated that there is a probable tonnage of 14,000,000 tons with an average value of $1.20 per ton in gold.

Besides the areas referred to, there has been exposed by erosion and shallow prospect shafts and tunnels on other claims of the group, a potential tonnage of ore of commercial grade that will probably run into several million tons.

Proposed method of treatment: It has been determined by actual mill operations and numerous mill tests made on ore extracted from the Cliff and Santa Fe mines that the best method of treatment is as follows:

The crude ore from the Santa Fe area as mined is screened through vibrating screens to ½-mesh. The plus ½-mesh rejected goes to dump, while the minus ½-mesh is transported by aerial bucket tram to mill. The screen ration is 3.2 tons into one ton. Mill tests on ore from Santa Fe Mine show the average value of the minus ½-mesh material or screenings to be $6.20 per ton; the reject material approximately 90 cents per ton. Some Santa Fe ores averaging better than $5 crude go direct to mill unscreened but no primary grinding required.

Treatment consists of grinding in Hardinge mill to 35-mesh and rolls to 20-mesh; amalgamation on plates; cyanide treatment by counter-current air agitation on minus 35-mesh and concentration on minus 20-mesh. The recovery by amalgamation approximates 68% and with cyanide treatment 91%.

Mill tests on ore from Cliff Mine: Screen ratio, 3.6 tons into one ton of ¼-mesh, reject 30 cents per ton. Average crude value of ore before

screening was $1.70 per ton. Screenings carried $4.40 per ton. Cyanide treatment on this ore indicated a recovery of 86 to 91% of gold values by sand leaching without crushing the ¼-mesh screenings.

The property has certain economic features that make it possible to treat the large tonnage of low grade ore that has been exposed by Blackhawk Canyon for a distance of two miles by cheap mining and milling methods.

There is sufficient water on the property to operate a mill with a capacity of 200 tons. Additional gravity water can be secured for large operations close at hand.

Electric power can be secured from the Southern Sierra Power Company's line which runs within six miles of the property. It is stated that the total cost of mining and milling, based on treating 300 tons per day are as follows:

Mining, overhead and depreciation	$0.30
Screening	.05
Milling	.40
Total cost per ton of ore	$0.75

Mine equipment consists of tugger and electric hoists, compressor and air drills. Mill equipment consists of one 8-bucket aerial tram from Santa Fe workings, 5100 feet in length. Capacity of buckets 12

Mine working of Calle de Oro vein on west end Santa Fe Mine, Arlington Mining Corporation.

cu. ft. A new 16-bucket aerial tram 4300 feet long from Santa Fe Mine to the mill has just been completed. The pilot mill has been enlarged to 200 tons per twenty-four hours.

Equipment consists of Hardinge mill; two sets of 20″ x 12″ rolls; Dorr duplex classifier; amalgamation plates; four 20′ x 8′ Dorr thickeners; four Pachuca air agitators, and complete cyanide equipment; two Diester plate tables and rake dewaterer for coarse sands. The power

plant consists of one 37½-h.p. type Fairbanks-Morse semi-diesel engine; and one 50-h.p. Fairbanks-Morse semi-diesel engine drives a 45 k.w. generator that furnishes electric power with a 15 k.w. emergency generator. Twenty-five men are employed.

Plans are being prepared for the installation of a 1000-ton sand leaching cyanide plant for treatment of ores from the Cliff Mine area. This unit will entail the mining of approximately 3600 tons per day by caving and electric shovel, screening to ¼-mesh, conveying by belt conveyor to the cyanide leaching tanks. No crushing required.

Mine equipment consists of tugger hoist, compressor and air drills. Mill equipment consists of one two-bucket aerial tram from Cliff workings, 557 feet in length. Capacity of buckets 12 cu. ft.; also ¼-inch trommel. Bunkers and aerial bucket tram from *Santa Fe Mine* to the

200-ton cyanide plant, Arlington Mining Corporation, Blackhawk Canyon, San Bernardino County.

mill. The mill has a capacity of 200 tons per day. Equipment consists of Hardinge mill; Dorr duplex classifier; amalgamation plates; Dorr thickener and two Plato tables; and cyanide plant. The mill is driven by one 37½-h.p. Y type Fairbanks-Morse semi-diesel gas engine; a 25-h.p. Fairbanks-Morse horizontal semi-diesel engine drives generator that furnishes electric power for operating motor that drives compressor at the Santa Fe Mine. Twenty men are employed.

Bibl: State Mineralogist's Reports IX, p. 226; X, p. 524; XI, p. 364; XII, p. 230; XIII, p. 330; XV, pp. 797–798.

Armistice Claim (formerly the *Pathfinder*) is in T. 5 N., R. 2 W., S. B. M., about 15 miles east of Victorville. Owner, A. C. Watson and W. T. Elliot, Hesperia, California.

Quartz vein in granite. Strike N. 60° W., dip 58° to the south. Vein varies from 4 to 6 feet; quartz from a few inches to 2 feet. There is an 85-foot incline shaft on the property. Idle.

Bagdad-Chase Mine. (See under Copper. Pacific Mines Co.)

Bald Eagle Mining Company has 2 claims in the San Bernardino Mountains, 1½ miles northeast of Yucaipa. They are in Sec. 31, T. 2 S., R. 1 W., S. B. M. T. Tally, Yucaipa, California, is president of the company.

Stringers of quartz and clay gouge occur on each side of a felsitic dike in granitic gneiss. The dike has a width of 4 to 6 feet. Strike N. 65° E., dip 65° to the north. The quartz stringers vary in width to a maximum of 12 inches and are reported to carry some gold.

Development consists of 70-foot tunnel and 25-foot winze. A small cyanide plant was erected.

Barrett Mine (*Hamerback and Patterson Group* of Mines). The property comprises 10 claims located 12 miles southeast of Cima, on the east slope of the Providence range of mountains. Elevation 5400 feet. Owner, *California-American Mining Company;* Dr. Orman Lutz, president; J. E. Miller, secretary.

The vein occurs in granite; strike north and south, dip 70° E. The width varies from 14 inches to 3 feet. The orebodies are in the form of lenses of quartz along the fissure. The vein quartz is mineralized with galena, pyrite and chalcopyrite said to carry from $6 to $25 per ton in gold. Development consists of three shafts. The main shaft has been sunk on the vein to a depth of 320 feet. There are two other shafts on the vein to a depth of 100 feet. Drifts have been driven on the vein on 50-foot, 100-foot, 200-foot and 300-foot levels. On the 100-foot level there is a drift south 450 feet, north 65 feet; on the 200-foot level, a drift north 65 feet and south 240 feet. On the 300-foot level there is a drift south 65 feet and north 65 feet. It is reported that 35,000 tons of ore have been developed above the 300-foot level. Idle.

Bibl: State Mineralogist's Report XV, p. 816.

Belmont Mine. It is located in the Goldstone Mining District, 34 miles northeast of Barstow. Elevation 3300 feet. Owner, Belmont Mining Company; Dr. W. W. Ramsey, president; George I. Drumm, secretary. Offices, Stockton, California. Holdings comprise 21 claims, totaling 420 acres.

The present development work is confined to the Belmont group, consisting of 5 claims.

Two parallel quartz veins occur in shales and schist, strike N. 60° W., dip 25° to the northeast. The veins vary in width from 12 inches to 3 feet. The ore is free-milling, with some pyrite.

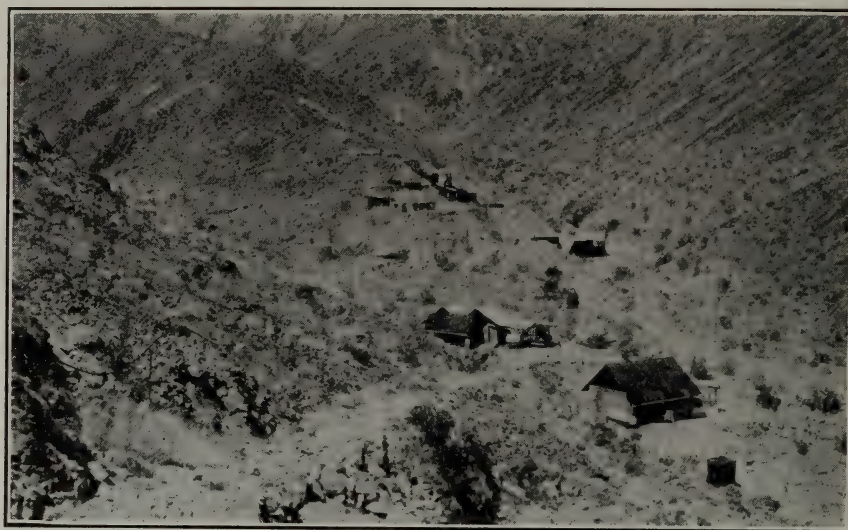
Development consists of a number of shafts sunk to depths of 50 to 300 feet on the different veins. The main shaft is 400 feet deep, sunk on an incline of 35°. Between 100 and 160 feet below the collar of the shaft the vein has been faulted by strike fault. On the 160-foot level there is a drift west on the vein for a distance of 50 feet. On the 230-foot level the vein has been drifted on 160 feet west. On the 330-foot level there is a drift west 50 feet. The ore extracted from these workings is reported to carry from $8 to $25 per ton in gold. Some high-grade ore was shipped from the property during 1916 and 1917.

Mine equipment consists of 25-h.p. gas-driven hoist, 7½-inch by 6-inch Chicago pneumatic compressor; air drills; blacksmith shop and cars.

Mill equipment consists of 25-ton ball mill and amalgamation plates. Idle.

Bibl: State Mineralogist's Report XX, pp. 46–47.

Big Horn Group, consisting of 3 claims, is located in the Granite Hills, 16 miles east of Victorville. Owners, Wm. Walsh, Ray Wilson, D. W. Smith and W. T. Elliot, Hesperia, California.



Brooklyn Mine and Camp. Dale District, San Bernardino County.

Three-stamp mill on Los Angeles Group. Dale Mining District, San Bernardino County.

Quartz vein accompanies a diorite dike in granite. The strike is NW., dip vertical. Forty-foot vertical shaft is the only development. Reported values of $16 in gold per ton. Idle.

Brannigan Mine (*Brooklyn and Los Angeles Mines*). It comprises a group of 15 claims located in the Dale Mining District, 45 miles northeast of Mecca, and 30 miles south of Amboy, a station on the Santa Fe Railroad. Elevation 2000 feet. Owner, *Campbell Gold Lease Company;* John L. Campbell, president; Dewey M. Campbell, secretary. Offices, Fuller Building, San Bernardino, California. Under lease and bond to O. B. Aman of San Bernardino, California.

The country rock is granodiorite with intrusions of dorite and diabase dikes. There is a series of five parallel veins that occur in the granodiorite, which are about 1000 feet apart. The most important veins are known as the Brooklyn and Los Angeles veins, and therefore most of the development work is confined to these two veins. The veins strike northwest and southeast and dip 70° to the northeast. These veins vary in width from 2 to 6 feet. The vein quartz is stained with iron and copper oxides.

Development consists of 17 shafts, with depths ranging from 25 to 750 feet deep. The total underground development amounts to 8500 feet.

Brooklyn vein: The total length along the vein is 4500 feet. Development: A tunnel has been driven on the vein northwest 550 feet about 100 feet below the vein outcrop. At 300 feet northwest of portal, a winze has been sunk on the vein to a depth of 200 feet. No. 1 level is 120 feet below tunnel level, and on this level the vein has been drifted on southeast 300 feet, connecting with a shaft 100 feet deep sunk from the surface, at a point near portal of tunnel. Northwest of winze there is a drift 75 feet to fault. The fault strikes N. 40° E., and dips 85° SE., and has displaced the vein 75 feet to the northeast. No ore was found beyond this fault on the different levels.

No. 2 level, at 110 feet below tunnel level, drifts 170 feet southeast and 170 feet northwest.

No. 3 level, at 150 feet below tunnel level, 245 feet of drifts on the vein.

No. 4 level, at 200 feet below tunnel level, 75 feet of drift on the vein. It is estimated that there is 4000 tons of ore developed that has an average value of $16 per ton, with 1 to 3 ounces in silver per ton. Two ore shoots were developed and stoped, one was 100 feet in length and the other 200 feet in length, with an average width of 4 feet.

There are about 5000 tons of tailings below the mill that, it is stated, will average $7 per ton in gold. The total production of the Brooklyn Mine is reported to be $150,000. The vein was discovered in 1893 and operated by the *Brooklyn Mining Company* from 1901 to 1916.

Los Angeles Group: It comprises 4 claims, with 4500 feet on the lode. On Los Angeles No. 3 claim, a shaft has been sunk on the vein to a depth of 750 feet, and 540 feet northwest of this shaft there is a shaft 250 feet deep that connects with No. 2 level of the main shaft.

On 52-foot level drift NW. 725 feet; 120-foot level drift NW. 365 feet; 320-foot level drift NW. 225 feet; 420-foot level drift NW. 175 feet; 685-foot level drift NW. 658 feet.

Only a small amount of stoping has been done above 120-foot level and considerable ore is exposed on the 52-foot and 120-foot levels. The estimated ore reserves in the Los Angeles Group are about 50,000 tons, with an average value of $9 per ton in gold. Below the mill there is 2000 tons of tailings, said to have an average value of $6 per ton in gold.

Equipment: On Brooklyn group of claims there are three 750-pound stamps with 30-ton rod mill. On Los Angeles group of claims there is a mill with three 250-pound stamps. A cyanide plant having a capacity of 40 tons per 24 hours has been installed at the Los Angeles Mine. Water is secured from the Supply Well. Fifteen men are employed.

Bibl: State Mineralogist's Report XV, p. 802.

Calmont Mine, consisting of 11 claims, is 19 miles southeast of Amboy. Owner, G. M. Benjamin, Amboy, California.

The property was worked in 1927 by the Calmont Mining Company. George Parks, Frank Tilton and Del Page of Barstow, California, were connected with this operation.

This mine was not visited but it is reported that a heavily iron-stained quartz vein, in granite, averages 2½ feet in width. Strike E.-W., dip about 70° to the south.

Development consists of 200-foot shaft, sunk on the vein, with drifts of about 100 feet each on the 100-foot and 200-foot levels. It is also reported that the gold values in the vein exposed in these workings will average about $15 per ton. There are two other parallel veins on the property, one of which is reported to be larger and stronger than the one on which the work has been done.

Idle except for assessment work.

Camp Castle Mine (formerly the *Great Gold Belt Mine*) comprises 5 claims in the Bristol Mountains, 14 miles northeast of Amboy. Owner, E. M. Streeter, 1505 Hope Street, South Pasadena, California.

This property probably was worked by Indians many years ago, remains of old arrastras having been found in the wash. It was rediscovered in 1907 and the Great Gold Belt Mining Company did some work on it at that time. It was relocated by the present owners about 1923.

The country rock consists of rhyolite, andesite, diorite and granite. The mountain to the southwest is capped with volcanic tuff which is several hundred feet in thickness. Several veins cross the property. The strikes vary from N. 40° E. to N. 65° E., dip from 70° SE. to vertical.

The principal vein, which is traceable on the surface for about 2200 feet, strike N. 65° E., dip 70° S., has an average width of about 2 feet, varying from a few inches to 5 feet. Its north wall is dolomite, the south wall is diorite. This vein appears to be faulted in perhaps two places. The fault is along a northwest-southeast line, with a displacement of some 25 feet.

Two incline shafts, each 275 feet deep, were sunk on this vein. It is reported that these two shafts intersect at the bottom. They are also connected on the 100-foot level. It is reported that there is some drifting on the 200-foot level and that the average width of the vein in these workings is 2 feet. Massive sulphide ore shows on the dump. These workings were inaccessible (filled with water) at the time of visit.

Present work is being done at a point about 250 feet northeast of these shafts. Here a shaft is being put down; present depth is 25 feet. The vein as here exposed shows 2 feet of quartz, one foot of talc and schistose country rock, and 1½ feet of quartz, the full width showing mineralization with the free gold content being confined to the

quartz. General samples from this work are reported to run from $4 to $18, with a general average of $12.

In the gulch several hundred feet southwesterly from these workings much surface work has been done. Also two shafts about 70 feet deep have been connected and about 200 feet of drifting was done here. It is reported that many high grade samples were taken from these workings.

Water has been developed by means of a 35-foot shaft and a 60-foot crosscut on the southeastern portion of the property. Also the old workings are under water from the 100-foot level down.

A small jaw crusher and a 3-foot Herman ball mill (no plates) are now on the property, together with a 15-h.p. Fairbanks-Morse semi-diesel engine; 2 small pumps with gas engines to operate them. Idle.

Camp Rock Placer Mine, consisting of 3 lode claims and 9 placer claims, is in Sec. 28, T. 7 N., R. 3 E., in the Bessemer Mountains, 25 miles northeast of Box S Ranch and 47 miles (by road) from Victorville. Owners, Charles Pohl and Henry C. Stock of Los Angeles.

These claims lie on the detrital slope at the foot of the Bessemer Mountains, on the southwest side. At this point the mountains consist almost entirely of granite. The drainage is to the southwest into a valley which also receives drainage from the southwest slope of the Ord Mountains. A narrow drainage channel on this slope has been prospected for about 1000 feet of its length. The work consisted of shallow pits and open cuts. The gravel removed was treated by dry washers and in the following plant:

Material delivered by trucks to pockets, with grizzly, elevated to trommel; thence to bin and sluice box about 50 feet long.

Bedrock, where exposed, is from 15 to 25 feet below the surface. A well sunk to a depth of 210 feet on the property is reported to yield 6 gallons of water per minute. Idle.

Christie Mine. It is situated near the Rose Mine, in T. 2 N., R. 3 E., 40 miles southeast of Victorville, in the Black Hawk Mining District. Idle.

Bibl: State Mineralogist's Reports XII, p. 231; XV, p. 796.

Clipper Mountain Mine. It is situated in the Gold Reef Mining District, about 5 miles northwest of Danby. Holdings comprise 8 claims. Owner, Clipper Mountain Gold Mining Company; B. G. Doak, president; A. H. Hayes, secretary. Offices, I. W. Hellman Building, Los Angeles.

The vein is 10 to 80 feet wide, strikes northwest and southeast, dip 60° SW. The footwall is rhyolite, with andesite as the hanging wall. The ore occurs as free gold in quartz-calcite veins.

Development consists of vertical shaft 300 feet deep. Operations were suspended in 1920 due to encountering a heavy flow of water on the 300-foot level. Idle.

Bibl: State Mineralogist's Report XVII, p. 345.

Colosseum Mine. It comprises 58 unpatented claims and 2 patented claims known as Colosseum No. 1 and Colosseum No. 2, located in the north end of the Clark Mountains, in T. 17 N., R. 13 E., S. B. M., 12 miles west of Calada, a station on the Union Pacific Railroad, and 10

miles north of Valley Wells. Elevation 5500 to 6100 feet. Owner, Colosseum Mines, Inc.; C. H. Gowman, president; Earl Thomas, secretary. Offices, 401 Bank of Hollywood Building, Hollywood, California.

The formations in the vicinity of the Colosseum Mine are made up largely of granite and of dolomitic limestone. The mine lies in the granite, which has been classified as monzonite, and the ore deposit occurs in an intrusive eruptive quartz-porphyry that has come up through the monzonite. About one-half a mile west of the mine is the contact of the dolomite and monzonite. The contact between the dolomite and the monzonite is marked by beds of shale and quartzite and shows no evidence of contact metamorphism. The orebody has evidently been formed by mineralization within a zone of fracturing occurring in the intrusive quartz-porphyry. The quartz-porphyry is mineralized with pyrite and marcasite, carrying gold. The ore occurs along the joint planes and fracture planes. The orebody strikes N. 60° E., and dips 80° SW., and is in the form of a chimney or a longitudinally shortened lens, and it is shown to be continuous in grade and character for a vertical distance of about 200 feet.

Developments consist of a tunnel located on the east slope of the hill, at an elevation of 6000 feet, driven N. 25° W., 800 feet. At 120 feet from portal, cut first ore which shows a thickness of 50 feet. At 225 feet north of portal, a drift has been driven N. 60° E., a distance of 80 feet and 90 feet to the southwest, exposing 100 feet of ore. Two orebodies have been developed on this tunnel, one being 50 feet wide and 100 feet in length, one 60 feet wide by 125 feet in length. A shaft has been sunk to a vertical depth of 200 feet, with levels at 100 and 200 feet. Crosscuts have been driven north on the 100 and 200-foot levels, 350 feet, with drifts to southwest in the orebody.

The ore developed in tunnel and shaft is said to have an average value of $7 per ton in gold, with occasional mineralized areas carrying as high as $30 per ton in gold. 26.7 tons of ore mined from tunnel level and shipped to the United States Smelting, Refining and Mining Company, carried 0.73 ounces gold, 1.1 ounces silver, 0.2% copper, with gross value of $14 per ton. Shipment of 39.6 tons carried 0.44 ounces gold, 0.85 ounces silver, 0.1% copper, with gross value of $8.46 per ton. Ore reserves, 50,000 tons having an average gross value of $7 per ton.

Present development is confined to driving a tunnel, at an elevation of 5800 feet, which will connect with the bottom of the vertical shaft; the distance to be driven is 550 feet.

Water is secured from shaft of the old Mojave Tungsten Mine, now owned by the company.

Mine equipment consists of duplex Deming (5-inch by 6-inch) pump driven by 25-h.p. gas engine; cement reservoir, capacity 60,000 gallons; cement reservoir at mine, capacity 35,000 gallons; one 180-h.p. Fairbanks-Morse diesel engine; 3-cycle water-cooling tower; one 210-cu. ft. Gardner-Denver compressor; one 115-cu. ft. Gardner-Denver compressor.

Mill equipment consists of 50-ton ball mill; Wilfley tables; and Simpson flotation machines. Fifteen men employed.

Bibl: State Mineralogist's Report XX, pp. 92–93.

Coolgardie Placer Mines, comprise a group of 4 claims, located at Coolgardie, in Sec. 29, T. 32 S., R. 46 E., 15 miles north of Barstow. Owner, Ira Forman, Torrance, California.

These placers have been worked at intervals since 1900 by dry washers and concentrators. The Coolgardie placers are reported to have had a production of $100,000 to date.

Bibl: State Mineralogist's Report XV, p. 817.

Columbia Mine. (See under Copper.)

Darling Mine. It comprises a group of 20 claims located in the Vanderbilt Mining District, 4 miles east of Ivanpah, a station on the Union Pacific Railroad. Elevation 5000 feet. Owner, Chas. C. Darling, Ivanpah, California.

There are two vein systems on this property, one being a series of north and south veins, the other being a series of east and west veins. The veins of both series are roughly parallel. The formation is granite. The veins vary in width from 3 to 6 feet.

Developments: On the Midnight claim, a shaft has been sunk on an incline of 60° to a depth of 266 feet. The vein strikes north and south and dips 60° W. The vein has a width of 3 feet. At a depth of 90 feet encountered sulphide ore. The vein quartz is mineralized with pyrite and stated to carry values of $10 to $20 per ton in gold. Drifts have been driven on the vein on the 65 and 165-foot levels. On the 65-foot level there is a drift north 30 feet and south 225 feet. On the 165-foot level there is a drift north 125 feet and south 125 feet. About 700 feet north of this shaft on the Crystal claim, there is a shaft 165 feet deep, with drifts on the 50 and 80-foot levels. This shaft is sunk near the intersection of a north and south and east and west vein. The Midnight and Crystal veins, which strike north and south, are roughly parallel and about 50 feet apart.

Mine equipment consists of 2-drill Sullivan compressor; 12-h.p. single-drum hoist; and Sullivan tugger hoist. Idle.

Desert Gold Placers. It comprises a group of 115 placer claims, located on Desert Lake, 6 miles east of Ivanpah and 10 miles south of Roach, a station on the Union Pacific Railroad. Owner, Desert Gold Dredging Company; H. P. Ewell, president; George W. Cram, secretary. Offices, 415 Union Oil Building, Los Angeles.

Gold occurs in unconsolidated sands and gravel of the dry lake bed. It is reported that pay gravel has been proved to a depth of 3 to 6 feet by test holes. The gravel is reported to carry 20 cents per cubic yard in gold. Idle.

Bibl: State Mineralogist's Report XVII, p. 345.

Elkhorn Mining Company (property formerly known first as *Golden Era,* then the *Silver Basin*), consists of the following claims: Golden Era, Hidden Treasure, Ransome, O'Farrell, Fraction, Mondan Fraction and Y. W. Fraction, a total of 60 acres, located in Sec. 7, T. 30 S., R. 41 E., M. D. M., 2½ miles southeast of Randsburg. Elevation 3600 feet. Owner, *Silver Basin Mining Company;* A. J. Rubenstein, president; Bradley Benson, secretary-treasurer, 462 South Spring street, Los Angeles.

Two parallel quartz veins occur in the schist, strike NW., dipping 70° NE. Width is 12 inches to 3 feet. There is also a series of north-south fractures which appear to be stronger than the northwest-southeast fissures. These have widths up to 5 or 6 feet and are filled with brecciated wall rock, partially cemented with quartz.

Development: There is a 240-foot shaft on the Hidden Treasure claim. Present work is confined to the Golden Era, where the shaft was sunk to 100 feet and 750 feet of drifts and crosscuts were driven; also a raise was put up about 60 feet to tap a small stope from which 17 tons of ore was milled in the Black Hawk mill, returning $17 per ton on the plates. It is reported that this shaft is now being sunk and that a vein, carrying high-grade tungsten ore on one wall and rich gold ore on the other, has been encountered.

Equipment consists of blacksmith shop; head frame; Sullivan air compressor, driven by 40-h.p. motor; and 50-h.p. motor-driven hoist. Seven men employed.

Bibl: State Mineralogist's Report XIX, p. 169.

Embody Mine. It is situated one-half mile east of Oro Grande. Idle.

Bibl: State Mineralogist's Reports XI, p. 361; XV, pp. 812–813.

Emerson Mine. It comprises a group of 10 claims located in the Dry Lake Mining District, 50 miles east of Victorville. Owner, Mrs. L. S. Emerson, Hodge, California.

A series of parallel veins in granite; strike NW. and SE.; dip 70° SW. The veins vary in width from 2 to 4 feet.

Development consists of a shaft 400 feet deep. Idle.

Equitibus Mine. It comprises a group of 8 claims, situated on the west slope of the Providence range of mountains, in the Kelso Mining District, 3½ miles east of Hayden, a station on the Union Pacific Railroad. Elevation 3300 feet. Owner, Equitibus Mining Corporation; John W. Baily, president; Patrick Cline, secretary; Joe Filmore, superintendent. Offices, Las Vegas, Nevada.

A series of parallel veins occur in granite, the veins being from 50 to 150 feet apart. The veins strike N. 50° E. and dip from 60° to 80° to the southwest. The veins vary in width from 12 inches to 4 feet. The vein quartz is mineralized with galena and pyrite, with gold and silver values. Three parallel, andesitic porphyry dikes, having a general north and south strike, occur in the granite, being about 1000 feet apart. The quartz veins cut through the dikes and show only slight displacement.

Development consists of five shafts and one tunnel on the different veins. The shafts are from 30 to 200 feet in depth, and one tunnel 100 feet in length. The principal development work is confined to No. 2 vein. On this vein an incline shaft has been sunk to a depth of 200 feet. Drifts have been driven on the vein on the 70, 150 and 200-foot levels. On the 150-foot level there is a drift southwest 200 feet. On the 200-foot level there is a drift to the northeast 230 feet. The vein exposed in these workings varies from 6 inches to 2 feet in width. The ore occurs in a series of short lenses of quartz along the fissure and passes from one wall to the other. About 800 feet southeast

of this shaft there is a shaft 80 feet deep, sunk on an incline of 80°. The vein exposed in this shaft is from 2 to 4 inches in width, the vein quartz being mineralized with galena and pyrite. About 50 feet to the north of this shaft is a parallel vein of quartz upon which no development work has been done. The vein quartz is stated to carry from $8 to $20 per ton in gold and silver, with 3 to 12% lead.

Mine equipment consists of 15-h.p. Novo single-drum gasoline hoist; 110-cu. ft. portable Rix compressor; and 2 Cochise jackhammers.

Eight men are employed.

Evan Davis Mine. It comprises 4 claims, located 50 miles east of Victorville. Elevation 5000 feet. Owner, Glenn A. Davis, Victorville, California. Idle.

Bibl: State Mineralogist's Report XV, p. 815.

Exchequer Mine. It comprises 5 claims, situated in the Dale Mining District, 4 miles south of Dale and 20 miles east of Twenty-nine Palms. Elevation 2000 feet. Owners, John McGrath and Al McRae, San Bernardino, California.

Development work consists of three shafts 40 to 110 feet deep. Idle.

Bibl: State Mineralogist's Report XV, p. 803.

Fremont Peak Mine is situated on the western slope of Fremont Peak, at an elevation of 3700 feet. Holdings consist of 12 claims, in T. 31 S., R. 41 E., S. B. M., 18 miles southeast of Randsburg. Owner, L. A. Mason, Oakland, California.

A series of parallel quartz veins occur in granite and also on the contact of granite and rhyolite-porphyry dikes. The veins have a general east and west course, dip 70° N., widths varying from 12 inches to 2 feet.

Development consists of an incline shaft 100 feet deep with levels at 50 and 100 feet. On the 50-foot level there is a drift west 125 feet and 100 feet east. Two tunnels have been driven on a parallel vein that occurs along a rhyolite dike. These tunnels are 100 and 200 feet in length. The average width of the veins is 12 inches and they are said to carry $25 per ton in gold. Idle.

Bibl: State Mineralogist's Report XIX, p. 172.

Frisco Group of Mines. It comprises a group of 5 claims located in the Kelso Mining district on the west slope of the Providence range of mountains, 7 miles east of Hayden, a station on the Union Pacific Railroad. Elevation 5000 to 5200 feet. Owner, Pete Thibdeau, Kelso, California.

These claims join the Providence Mine on the north and east. The formation is diorite and dolomitic limestone. The gold quartz veins occur in the diorite. There is a prominent rhyolitic-porphyry dike that strikes north and south. The dike is from 20 to 50 feet wide and can be followed for several miles along its outcrop. There is a series of parallel east and west veins that intersect this dike from the east. These veins are from 12 inches to 2 feet wide, with a high-grade streak on one wall.

On Frisco Claim No. 3, one ton of ore extracted from Short tunnel on one of these east to west veins and shipped to U. S. Smelting,

Refining and Mining Company, carried 2.17 ounces in gold, and 55.4 ounces in silver.

Development consists of a number of tunnels from 20 to 400 feet in length and shafts from 20 to 100 feet in depth. The principal development, however, is confined to Frisco No. 5 and Frisco No. 1 claims. On Frisco No. 5 claim, the vein strikes east and west and dips 60° south. Width of vein is 8 feet. A shaft is sunk on this vein to a depth of 100 feet. The vein quartz is mineralized with pyrite and galena and carries values in gold and silver.

On Frisco Claim No. 1, which is located 1 mile north of Providence shaft, at an elevation of 4800 feet, a tunnel has been driven southwest 400 feet; at 300 feet southwest of portal it intersects rhyolitic-porphyry dike. It is stated that samples cut across 35 feet of this dike carried $3 per ton in gold. At 200 feet from the portal a raise was put up to the surface on a cross-fracture, a distance of 50 feet. At 300 feet from portal, a winze was sunk to a depth of 30 feet, exposing 8 feet of sulphide ore said to have an average value of $15 per ton in gold. The vein quartz is heavily mineralized with iron pyrite. Idle.

Globe Mine. It comprises 7 claims located in the Kelso Mining District, on the west slope of the Providence range of mountains, 7 miles east of Hayden, a station on the Union Pacific Railroad. Elevation 5300 feet. Owner, Globe Gold Mining Company; George H. Thomas, president; A. C. Jones, secretary, Los Angeles.

The vein strikes east and west and dips 65° south. The vein varies in width from 4 to 8 feet.

Development consists of a tunnel 1000 feet in length. The vein quartz is mineralized with galena and pyrite, carrying values in gold and silver. Some very high-grade ore has been shipped from the property. Idle.

Gold Bar. (See Vanderbilt Mines.)

Gold Belt Mine (formerly the *McGinnis* or *Gold Peak Mine*). This property embraces 9 claims on the southwest slope of Goat Mountain, 30 miles slightly north of east from Victorville. Elevation 4500 feet. Owner, Gold Belt Mining Company; C. W. LaFountaine, president and manager; J. Davis, vice president, South Gate, California.

The country rock is granitic, largely monzonite and diorite. A fissure vein, varying from 2½ to 7 feet wide, filled largely with quartz and calcite and in places having a rhyolite casing on the hanging-wall side, strikes N. 40° E., dips 45° SE. This vein is traceable on the surface for about one-half mile. Mineralization consisting of free gold, pyrite and some chalcopyrite was observed in the ore on the shaft dump.

Development consists of an old vertical shaft 200 feet deep, with levels at the 50-foot, 100-foot and 200-foot horizons. On the 50-foot level there is a drift 50 feet southwest and 100 feet northeast, with a winze which is approximately 50 feet deep in the northeast drift.

One hundred-foot level: Drift about 50 feet southwest and 40 feet northeast.

Two hundred-foot level: Drift 75 feet southwest and 230 feet northeast, with a 25-foot winze in the northeast drift.

The vein shows strong and of good average width to this depth and is reported to carry good values.

About 1000 feet to 1200 feet southwest of this shaft and about 500 feet below its collar, a tunnel is being driven on the vein, N. 40° E. At the time of visit (December, 1929) this tunnel had a length of something over 300 feet. It was being driven to pick up the ore shoot below the bottom of the old shaft and to prospect the ground between.

Equipment consists of compressor driven by semi-diesel oil engine. It was reported in May, 1930, that a mill is being erected at this property.

Seven men employed on two shifts, driving the tunnels.

Gold Bronze Mine. It comprises 7 claims located in the Vanderbilt Mining District, adjoining the Vanderbilt Mines on the east, 4 miles east of Ivanpah, a station on the Union Pacific Railroad. Elevation 5200 feet. Owner, C. A. Bell, Ivanpah, California.

Two parallel veins occur in the granite, strike east and west and dip 70° N. The veins have an average width of 6 feet. The vein quartz is heavily mineralized with pyrite. The Gold Bronze shaft was sunk on the most northerly vein to a depth of 300 feet. The sulphide ore was encountered on the 100-foot level. The ore mined and milled was mostly oxidized gold ore.

About 200 feet south of the Gold Bronze shaft, a shaft was sunk on a parallel vein to a depth of 200 feet. The ore mined is stated to have an average value of $20 per ton in gold. Idle.

Bibl: State Mineralogist's Reports XI, p. 367; XII, p. 232.

Gold Bullion Mine, consisting of one claim, is in the Oro Grande Mining District, about 4 miles northeast of Oro Grande. It adjoins the Ozark on the south. Elevation about 3500 feet. Owner, J. F. Tedford, Oro Grande, California. Under lease to S. B. Hunnewell, on the property.

Quartz vein in andesite, strike N. 10° W., dip 60° W. The andesite is in the form of a dike about 60 feet wide. Where the main vein occurs the andesite is schistose from shearing stresses. Numerous cross stringers intersect this vein, which is about 18 inches to 2½ feet wide.

Development consists of a vertical shaft 80 feet deep. This is partially caved. Present operator is cleaning it out to investigate report that there is 30 inches of $70 ore in the bottom.

Two men are employed.

Gold Eagle Mine. It comprises 5 claims located 2 miles east of Burns Springs, and 20 miles north of Whitewater, in the Morongo Mining District. Owner, R. B. Brown, Los Angeles.

The vein occurs in the granite, strike north and south, dip 60° E. Average width of vein is 12 inches, said to have an average value of $15 per ton in gold. The occurrence of bismuth sulphide was noted in the quartz. Idle.

Gold King is in the Oro Grande Mining District, about 5 miles northeast of Oro Grande. It consists of 7 claims on which considerable tunnel work has been done. Owner, George Comas and associates, Hotel Haskell, Eighth and Wall streets, Los Angeles. Idle.

Gold King Mine. It is situated in the Gold Valley Mining District, about 16 miles south of Cima and 23 miles northwest of Fenner, on the east slope of the Providence range of mountains. Elevation 5000 feet. Owner, Gold King Mining Company; Burr H. Robbins, president, South Pasadena, California.

Development consists of a shaft 400 feet deep. Mill equipment consists of 25-ton rod mill with amalgamation plates and tables. Two men employed.

Gold Mountain Mine. This mine is situated in the San Bernardino range of mountains, north of Baldwin Lake in the Bear Villey Mining District. Elevation 7350 feet. Owner, James Hulmes, South Pasadena, California. Holdings comprise 16 claims, totaling 320 acres.

The vein system occurs as irregular bodies of massive quartz containing free gold. The strike of the orebody is N. 60° W., dip 30° to 60° south. The average width of the vein is 40 feet.

Development consists of a glory hole approximately 600 feet long by 40 feet wide and by 50 feet deep. An adit tunnel 700 feet long has been driven N. 60° W., 85 feet vertically below the outcrop. The ore mined from the glory hole is said to have an average value of $4 per ton in gold. There is a 35-stamp mill on the property. Idle.

Bibl: State Mineralogist's Reports XVII, pp. 346–347; XII, p. 232; XIII, p. 322.

Gold Reef Mines. Situated in Gold Reef Mining District, on the southeast slope of Clipper Mountain, 6 miles northwest of Danby, a station on the Santa Fe Railroad. Elevation 2700 feet. Owner, Gold Reef Mining Company, 600 I. W. Hellman Building, Los Angeles.

Ore occurs in a highly silicious rhyolite dike, strike northwest and southeast, dip 60° SW.

Developments consist of two shafts 100 and 500 feet in depth. Formerly operated under lease and bond by the Tom Reed Mining Company, of Oatman, Arizona, in 1917–1918, but operations were suspended due to striking a heavy flow of water on the 500-foot level. Idle.

Bibl: State Mineralogist's Report XVII, p. 346.

Gold Rose Mine. It comprises 15 claims situated in the Dale Mining District, adjoining the Los Angeles Group of Mines on the southwest, 45 miles northeast of Mecca, a station on the Southern Pacific Railroad. Elevation 1700 feet. Owner, Thomas Holmes, San Bernardino, California.

Four parallel veins occur in the granite. The veins strike northwest and southeast and dip 70° NE. The veins vary in width from 2 to 6 feet.

The development consists of five shafts sunk on the different veins that are from 25 to 250 feet in depth. Gold Rose No. 2 shaft is 235 feet deep sunk on an incline of 70°. Gold Rose No. 1 shaft is 100 feet in depth with drift on the vein on the 100-foot level for a distance of 200 feet. On Gold Rose Claim No. 4, a shaft has been sunk on a vein on an incline of 70°, with a drift south on the 100-foot level, a distance of 110 feet. From this level, a winze has been sunk on the vein to a depth of 30 feet. The vein has an average width of 4 feet. The vein quartz is mineralized with galena and stained with copper carbonates.

The ore mined is said to carry from $12 to $15 per ton in gold. Bunches of galena occur at intervals along the vein. Sorted lead ore is stated to carry 20 to 30% lead, with gold and silver values. Equipment consists of 6-h.p. gas engine hoist.

Goldstone Mine. It is situated in Goldstone Mining District, 33 miles northeast of Barstow, a station on the Santa Fe Railroad. Elevation 3600 feet. Owners, Goldstone Mining and Milling Company; J. M. Schofield, president; G. Marston Leonard, secretary, Boston, Massachusetts. Holdings of the company consist of 22 claims, totaling 440 acres.

A quartz vein occurs on the contact of limestone and shale. The vein has a course of north and south to northwest and southeast, and dips 40° E. Average width of vein is 4 feet.

Development consists of vertical shaft 300 feet deep. At a depth of 50 feet the shaft cuts through the vein, the remaining distance being in the limestone footwall. What ore was mined was extracted from open cut on the vein, which is 150 feet long. The ore from these workings is said to have averaged $40 per ton.

Equipment consists of 25-h.p. gas engine hoist, and a 12-inch by 12-inch Fairbanks-Morse compressor driven by 50-h.p. gas engine. Idle.

Bibl: State Mineralogist's Report XV, pp. 805–806; XX, p. 47.

Grand View Mine. It comprises 31 claims located on the southeast slope of Ord Mountain, in Secs. 9, 10 and 15, T. 6 N., R. 2 E, S. B. M., 18 miles northeast of Box S Ranch and 42 miles northeast of Victorville. Elevation 4100 feet. Owners, *Garvan Mining and Reduction Company, Ltd.*; R. E. Garrison, president; W. G. Van Horn, secretary, Victorville, California.

A series of parallel veins which strike N. 30° E. and dip 65° NW. occur in andesitic porphyry. The main development work has been confined to the Grand View vein, which has been exposed on the surface for a distance of 3000 feet along its outcrop. The vein has a maximum width of 15 feet, with an average width of 8 feet. The footwall of the vein is a granitic porphyry with an andesite hanging wall. The vein filling is brecciated rhyolitic-porphyry, highly silicified, iron stained with hematite, carrying free gold.

Development consists of a 2-compartment shaft sunk to a depth of 100 feet on an incline of 65°. At 38 feet below the collar of the shaft, the vein has been drifted on 70 feet. There is also a level at 98 feet from the collar of the shaft, with 75 feet of drifts.

The ore milled from these workings is said to have had an average value of $8.90 per ton in gold.

Both north and south of the Grand View shaft are some intrusive rhyolite dikes which strike north and south. East of the shaft there is an intrusive diabase dike that probably faults the vein north of the shaft.

Considerable development work has been done on the other veins, with open cuts and short tunnels. It is stated that samples taken from these veins carry from $10 to $20 per ton in gold.

Mine equipment consists of a 6-h.p. Fairbanks-Morse gas engine hoist. Mill equipment consists of three 1000-pound stamps driven by 15-h.p. gas engine; blacksmith shop. Three men employed.

Gypsy Queen Mine. It comprises 6 claims situated in the Dale Mining District, 15 miles southwest of Twenty-nine Palms. Elevation 1800 feet. Owners, James McCain and F. T. Moore, Twenty-nine Palms, California.

The vein strikes north and south, dips 70° W.; width 4 feet, with 2 feet of oxidized quartz on the footwall. The formation is granite.

Developments consist of a number of shafts from 50 to 100 feet in depth, with a number of shallow open cuts and short tunnels. The

Shaft and three-stamp mill. Grand View Mine, Ord Mountains, San Bernardino County.

principal development work consists of a shaft sunk on the vein to a depth of 125 feet, with levels at 50 and 100 feet and several hundred feet of drifts.

Mine equipment consists of 6-h.p. gasoline hoist. Idle.

Halloran Springs groups. (See pp. 321–333, *post.*)

Hamburger Placer Group consists of 360 acres, 15 miles east of Atolia. Owners, M. A. and D. A. Hamburger, Hillstreet Building, Los Angeles. Considerable test work has been done on this property. Highest values found are reported to have been 40c per yard, with no concentration at bedrock. Water was secured from 2 wells on the property. Idle.

Hello Al Group, comprising 12 claims, is 5 miles northeast of Oro Grande. Owners, A. R. Greenslitt, J. F. Tedford and J. L. Sterne, Oro Grande, California.

There are two parallel veins in rhyolite, about 80 feet apart. Strike E.-W., dip 35° S.; average width about 18 inches with 24 inches maximum. Vein filling consists of quartz and silicified wall rock which gradually shades into the unaltered country rock. These veins are traceable for a few hundred feet, disappearing under surface debris.

Development consists of an inclined shaft about 100 feet deep. It was inaccessible at time of visit. Reported to show 12-inch vein in bottom which carries $20 in gold per ton. Idle.

Hidden Hill Mines. This group of mines is situated in the Arrow Mining District, on the eastern slope of the Providence range of mountains, 20 miles west of Fenner, a station on the Santa Fe Railroad. Owner Claypole and associates, of Needles, Arizona.

A series of parallel veins occur in a granitic-porphyry, which is brecciated along these fractures. The veins are narrow, varying in width from 1 to 12 inches. The quartz contains jasper with high gold values. The veins strike N. 30° E., and dip 45° W. These veins are displaced by a number of north and south faults.

Development consists of an incline shaft 240 feet deep and a crosscut tunnel. This property has been noted for the high-grade ore pockets that have been extracted from the veins. During 1913, one pocket extracted amounted to 300 pounds, producing $13,000. One man employed.

Bibl: State Mineralogist's Report XVII, p. 348.

Holcomb Valley Placers. These gold placers are situated in Holcomb Valley, in the San Bernardino range of mountains, in T. 3 N., R. 1 W., S. B. M., 25 miles southeast of Victorville and 9 miles west of Doble. Elevation 7000 feet. Owners, H. J. Potter, San Bernardino, California, and W. E. Esplin, Los Angeles.

During 1917 the property was under operation by the Holcomb Valley Dredging Corporation, of Los Angeles. A number of test holes were put down on the property and a shaft on the property was unwatered and sampled.

The gold deposits of Holcomb Valley are a primary concentration from the erosion of the schist and porphyrys of the Gold Mountain region. It is a broad porphyry belt which crosses the country in a northwesterly and southeasterly direction, and can be traced for several miles. This belt is apparently full of numerous quartz stringers and pocket seams. In places the country rock for considerable widths will run three or four dollars per ton in gold. It is from the erosion of this belt that the Holcomb Valley placers are formed.

During the late eighties and early nineties these placers were worked by an English company by means of steam shovels and elevators. Most of this work was done along the edges of the deposit. It is stated that the material handled by this operation averaged 30 cents per cubic yard. There is an area of about 400 acres on Holcomb Creek, which varies in depth from ten to fifty feet, that may offer a possibility

for dredging operations. The only water available is that from Holcomb Creek, which has a flow of thirty to forty inches. Idle.

Bibl: State Mineralogist's Reports X, pp. 520–523; XII, p. 233; XIII, p. 323; XV, pp. 798–799; XVII, p. 349. Bull. No. N-92, p. 154.

Ivanhoe Mine. It comprises 13 claims, situated in the Dale Mining District, on the east slope of the Dale Hills, 2½ miles east of New Dale, and 22 miles east of Twenty-nine Palms. Elevation 3000 feet. Owner, Denny B. Pardo, San Bernardino, California.

Three parallel veins known as Top Nest, Hidden Treasure and Ivanhoe, occur in andesitic porphyry. The veins are approximately 600 feet apart, the Ivanhoe being the most easterly vein. The veins strike N. 20° W. and dip 80° E., to vertical. Widths of veins vary from 2 to 6 feet. The vein quartz is stained with copper oxides and shows considerable hematite and some free gold with chalcopyrite and bornite. The average value of the ore is reported to be $15 per ton in gold, with selected ore carrying $36 per ton in gold.

The principal development is confined to the Ivanhoe vein. On this vein a shaft has been sunk to a depth of 215 feet, with levels at 70 feet, 125 feet and 200 feet. On the 700-foot level there is a drift north 300 feet. On the 125-foot level there is a drift north 325 feet; on 200-foot level, a drift north 40 feet and south 50 feet. About 200 feet north of this shaft, there is a raise from the 70-foot level to the surface. A small amount of stoping has been done on the 70-foot level and the ore mined is said to have plated $16 per ton in gold. On the north end of the Ivanhoe vein there are two shafts about 200 feet apart, that are 90 feet in depth. On the Hidden Treasure vein there is a shaft 90 feet deep and a tunnel 100 feet in length. On the Top Nest vein, on the slope of the ridge north of Ivanhoe Canyon, there are four tunnels driven at different elevations, from 100 to 200 feet in length. The average width of the vein exposed in these workings is 2 feet.

Mine equipment consists of 15-h.p. gas-engine hoist. Mill equipment consists of 25-ton dry concentration plant. Idle.

Jim Boy Group of Claims. There are 7 claims in this group, situated in the Dale Mining District, about one-half mile southwest of the Supply Mine and 15 miles east of Twenty-nine Palms. Elevation 2200 feet. Owners, Everett Corthers and C. E. Cusick Estate, Dale, California.

The vein occurs in diorite, strikes N. 40° W., dip 70° NE.; width 12 inches to 3 feet.

Development consists of a shaft 40 feet deep and two tunnels, one 100 feet in length, the other 50 feet in length. One man employed.

Johnson's Mine. It is situated 18 miles east of Box S Ranch, and 4 miles south of Ord Mountain on the east slope of a low range of hills. Owner, R. A. Johnson, Victorville, California.

A quartz vein accompanies a diorite dike in gneissoid granite; strike north and south, and steep dip to the west. The vein varies from 12 inches to 4 feet in width; of this width from 4 to 10 inches is iron-stained quartz. The remaining portion consists of brecciated

wall rock, recemented with quartz. The entire width is mineralized with pyrite. The quartz carries free gold.

Development consists of a crosscut tunnel driven west 300 feet to intersect the vein. Drifts have been driven 140 feet south and 240 feet north on the vein. The maximum depth attained below the outcrop is 100 feet.

Equipment consists of 15-h.p. Fairbanks-Morse gas engine which drives a 2-drill compressor. One man employed.

June Group of Claims. These claims are situated in the Dale Mining District, 16 miles east of Twenty-nine Palms. Elevation 1800 feet. Owners, Cooper Bros., Twenty-nine Palms, California.

The claims adjoin the Gypsy Queen Group and are on the same vein system.

Development consists of shallow shafts and opencuts. Idle.

Keystone Mine. It comprises 3 claims situated 18 miles northeast of Victorville, near the Sidewinder Mine. Owners, J. T. Vetter, P. C. Markley and C. M. Richards, of Los Angeles.

Lester Mine comprises 11 claims situated on the north slope of the San Bernardino Mountains, about 4 miles east of Blackhawk Canyon, extending westerly from Arrastra Creek about 2 miles and about 40 miles southeast of Victorville. Elevation 4300 feet. Owners, D. J. Wheeler and W. F. Dall, San Bernardino, California.

On the east end of the property there is a quartz vein, strike N. 45° W., dip vertical. The northeast wall is a gneissoid granite and the southwest wall is granite. There is also a cross-vein, the strike of which is northeast. This, apparently, intersects the main vein about 200 feet northwest of a shallow shaft. Beyond this intersection, the vein traverses the country for probably a mile. In some places the vein is in limestone and then on the contact of the gneissoid granite and the limestone.

Development consists of a shaft 25 feet deep, and at a lower elevation a tunnel is being driven on the vein. The present length of the tunnel is 50 feet. Three men employed.

Lost Burro Mine. It comprises 7 claims located in Gold Valley, 16 miles south of Cima, a station on the Union Pacific Railroad. Elevation 5000 feet. Owner, Lee Strawn, Cima, California.

Vein strikes north and south and dips 37° W. The vein has an average width of 3 feet with 6-inch streak of high-grade ore on hanging wall. Average grade of ore is $25 per ton in gold.

Development consists of an incline shaft 125 feet deep. Idle.

Mabel, Contention and Investment Group of Mines, comprises 12 claims located in the Arrow Mining District, 23 miles northwest of Fenner, on the eastern slope of the Providence range of mountains. Elevation 3750 feet. Owner, Wm. E. Wilson, Long Beach, California.

The formation is composed principally of granite, diorite, quartzite and porphyry. A series of parallel, intrusive dikes of porphyry occur in the quartz-monzonite. The dikes have a general north and south trend. The quartz veins occur on both walls of these intrusive dikes. The veins vary in width from a few inches to 4 feet. The veins have a N. 20° E. strike, dip 40 to 75° W. There are also a number of veins

which have an east and west strike and dip south, the most notable being the Contention and Big Ledge veins. The latter is 10 to 12 feet wide. The ores are siliceous in character and contain values in gold, silver and copper, the principal value being gold. The ore is reported to carry from $6 to $80 per ton in gold. The production is reported to have been about $100,000, all of which was shipped to the smelters. Only ore exceeding $50 per ton was shipped. Oxidized zone extends to a depth of 100 feet.

Developments: The Contention shaft, sunk on east and west vein to a depth of 230 feet, with levels at 65 feet, 100 feet, 144 feet and 200 feet. Mabel shaft, 140 feet deep, sunk on north and south vein. Sulphide ore was encountered at a depth of 120 feet. The Mabel vein has a width of 12 feet with a 12-inch streak on footwall that is said to carry from $25 to $100 per ton in gold. It is stated that samples taken for the full width of the vein had an average value of $9 per ton of gold. There are a number of other shafts sunk on the different veins to depths of 50 to 100 feet. Idle.

Bibl: State Mineralogist's Reports XV, p. 801; XVII, p. 349; XX, pp. 196–198.

Massen Group of Claims, comprises 87 claims, located on the northwest slope of Alvord range of mountains, in Secs. 26–35, T. 12 N., R. 3 E., 32 miles northeast of Barstow. Elevation 2400 to 3100 feet. Owner, J. H. Massen and associates of Los Angeles.

A number of parallel, narrow quartz veins occur in the granite. These veins have a general course of northwest and southeast, with dips varying from 40° to 60° to southwest. The veins vary in width from 2 inches to 2 feet.

Developments consist of a number of shallow shafts and short tunnels. Idle.

Bibl: State Mineralogist's Report XX, pp. 47–48.

Morning Star Mine. It comprises a group of 18 claims, situated in Secs. 27, 28, 33 and 34, T. 15 N., R. 14 E., S. B. M., on the east slope of the Ivanpah range of mountains, in Mescal Mining District, 8 miles north of Cima. Elevation 4400 feet. Owners, J. B. Mighton and H. T. Brown, Cima, California.

The vein occurs as a rhyolite-porphyry intrusive in quartz-diorite, which strikes north and south and dips 34° west. The width of this porphyry dike is about 350 feet. The vein material is highly silicified and the mineralization occurs along a series of more or less parallel east and west fractures in the dike itself. The ore is quartz, heavily mineralized with pyrite, of which it is stated 20 to 40% of the values are in free gold, the remaining values being in the pyrite. The values vary from $3 to $15 per ton. Samples taken by different engineers across a width of 280 feet are said to have an average value of $4.37 per ton in gold.

Development consists of a tunnel driven 600 feet along the footwall of the dike. which is 350 feet vertically below the outcrop. At a point 185 feet north of the portal, No. 1 crosscut is driven west 96 feet. Channel samples cut at 5-foot intervals in this crosscut, it is stated, carried an average value of $4 per ton in gold. At 450 feet north of portal of the tunnel, No. 2 crosscut is driven west 285 feet. From this

point the course of the tunnel is changed to N. 20° W. and is in the vein-dike for the remaining distance of 150 feet. At 550 feet north of portal, No. 3 crosscut is driven east 40 feet to the footwall. About 30 feet north of this crosscut, a winze has been sunk to a depth of 50 feet below the tunnel level and at this depth the winze encounters the footwall. The ore extracted in sinking this winze is reported to have an average value of $15 per ton in gold. Estimated tonnage of ore above tunnel level is said to be 2,000,000 tons with an average value of $4.37 per ton in gold. About one mile south of the Morning Star tunnel, on the Kewanee Claim, there is an outcrop of quartz 20 to 50 feet wide, strike north and south, dip 34° W. A shaft has been sunk to a depth of 125 feet on a 65° incline.

Equipment consists of Gardner-Denver compressor driven by Lozier automobile engine; air drills and blacksmith shop. Two men employed.

Morongo King Mine. It comprises 3 claims situated in the Morongo Mining District, in T. 2 N., R. 5 and 6 E., S. B. M., 46 miles north of Seven Palms, a station on the Southern Pacific Railroad. Elevation 5000 to 6000 feet. Owner, Morongo King Mining Company, San Bernardino, California.

The vein strikes northeast and southwest and dips 65°; width of vein 4 feet. The vein quartz carries a large percentage of pyrite, with some free gold.

Development consists of shaft 180 feet deep. with drifts on 100-foot level. Idle.

Bibl: State Mineralogist's Reports VIII, p. 504; IX, p. 266; X, p. 526; XII, p. 234; XIII, p. 324; XV, p. 800.

Mountain King Group is in the northwest end of the Turtle Mountains, 10 miles north of Salt Marsh, a station on the Parker cut-off of The Atchison, Topeka and Santa Fe Railroad. It comprises 7 claims. Owners, Thomas Schofield, Amboy, California, and A. L. Doran, Barstow, California.

It is reported that a brown, porphyritic dike in schist, from 300 feet to 400 feet wide, is mineralized across its full width. Quartz veins and stringers cut this dike, the strike of which is NW.-SE., and dip about 65° to the northeast. Average values across the full width are not known, but samples across 6 and 16 feet are reported to have assayed $40 and $5.40, respectively.

Development consists of an incline shaft 100 feet deep and a tunnel 100 feet long, together with open cuts. Average width of quartz vein in shaft is reported as 20 inches and average value $20 per ton.

There is no water on the property, but there is a well four miles distant.

This property was not visited, the above information having been furnished by Mr. Scofield. Idle except for assessment work.

Murray Mining Company has leased 8 claims (the old *Henshaw Mine*) from the Holcomb Bros. and Phoebe Henshaw. This property is on the north slope of the San Bernardino Mountains in the Silver Creek District, 27 miles (by road) southeast of Victorville. Elevation 4300 feet. Murray Mining Company; Whitham Murray, president, 502 Security Title Insurance Building, Los Angeles.

A crosscut driven south in the face of the mountain, a distance of 300 feet, cuts a series of narrow shale beds, alternating with granitic dikes. The sedimentaries are crushed and broken, forming an incoherent mass. A few feet from the face of this crosscut, a drift has been driven east about 15 feet and west the same distance, along one of these contacts. At the base of the east drift, a raise about 100 feet high has been driven to the surface. It is reported that this broken material, for a width of 30 feet at the contact, carries gold values. Pannings of a general sample taken at this point failed to show any gold.

Excavations for a mill were being made just below the portal of this tunnel at the time of visit. Four men employed building the mill.

Myrick Mine. It comprises 7 claims situated 40 miles east of Johannesburg. Owner, F. M. Myrick, Johannesburg, California.

A vein of quartz strikes northwest and southeast, reported to carry $30 per ton.

Development consists of shallow prospect shafts and open cuts. Idle.

Bibl: State Mineralogist's Report XIX, p. 63.

Nichols Mine. It is situated in the Morongo Mining District, 46 miles north of Seven Palms, a station on the Southern Pacific Railroad. Elevation 5500 feet.

The vein is 12 feet wide, strike northeast and southwest. Development consists of four shafts, from 20 to 100 feet in depth. Idle.

Bibl: State Mineralogist's Report XV, p. 800.

North Star and Big Blue Group of Mines. These claims are in the Big Bear Valley Mining District, 45 miles east of Victorville. Owner, Al Watts, Victorville, California.

A vein 2 feet wide occurs on contact of limestone and mica schist; strike east and west; dip 45° N. It adjoins the Rose Mine. Development consists of 300-foot tunnel driven on vein. Idle.

Bibl: State Mineralogist's Report XVII, p. 350.

O. K. Mine. It comprises 5 patented claims located in T. 1 S., R. 12 E., S. B. M., situated in the Dale Mining District, 20 miles east of Twenty-nine Palms. Elevation 2350 feet. Owner, Seeley Mudd Estate and Philip Wiseman, of Los Angeles.

The vein strikes N. 20° E., dips 70° and occurs on contact of adesitic-porphyry and quartz-monzonite, the latter being the footwall of the vein. The vein varies in width from 2 to 6 feet. The vein quartz is iron-stained, and carries some free gold.

Development consists of 2-compartment incline shaft sunk to a depth of 800 feet. Considerable drifting has been done on the vein from the different levels. It is stated that the average grade of ore mined and milled was $9 per ton in gold. There is a 10-stamp mill on the property, weight of stamps being 1000 pounds per stamp. The reported production of the property is over $200,000. Idle.

Olympus Mine (*Paradise*). This property is situated on the south slope of the Paradise range of mountains, at an elevation of 2300 feet, 22 miles north of Daggett. Holdings comprise 7 claims. Owner,

Olympus Gold Mining Company; S. E. Bagley, president; M. W. H. Williams, secretary, San Bernardino, California.

A series of parallel veins occur in granite, strike N. 30° W., dip 33° NE. Width of veins vary from 6 to 20 feet.

The principal development work has been confined to the Klondike vein. There is an incline shaft sunk on the vein to a depth of 400 feet. At the elevation of this shaft, a tunnel has been driven north 400 feet on the vein. The vein in this tunnel has an average width of 6 feet of quartz, and in places there are lenses of quartz 20 feet in width. About 50 feet vertically above this tunnel, there is a tunnel 300 feet in length on the same vein; the lower tunnel is connected with this tunnel by a series of raises. At 365 feet from the portal of the lower tunnel, the vein is cut off by a fault which strikes N. 45° E. It is reported that 50,000 tons of ore has been developed above the lower tunnel that will average $6 per ton in gold. A lower tunnel 400 feet in length connects with shaft on 400-foot level. Only a small amount of drifting has been done on the vein from the levels in the shaft. On 135-foot level there is a drift 100 feet on the vein; on 235-foot level, drift south 50 feet. The mine is supplied with water from Paradise Springs, a distance of 2½ miles.

Equipment consists of 25-h.p. gasoline hoist; 9-inch by 8-inch Ingersoll-Rand compressor. Ten stamp mill driven by 40-h.p. gas engine and one Gibson mill. Idle.

Bibl: State Mineralogist's Report XVII, p. 350.

Ord Belt Mine consisting of 9 claims is in Secs. 4 and 10, T. 6 N., R. 2 E., on the southwest slope of Ord Mountain, about 21 miles east of Box S Ranch. Elevation approximately 5100 feet. Owner, W. A. Raymond, 2209 Carmona avenue, Los Angeles.

The rocks exposed on the property consist of monzonite, rhyolite, rhyolite-tuff, andesite and dacite. The rhyolite occurs both as capping and in dikes. There are two systems of veins. The north-south veins occur in the dacite, or largely so. while the northeast-southwest veins occur at the contact of the rhyolite with the monzonite. The veins vary in width from a few inches to four or five feet. The vein filling consists of quartz from 3 inches to 2 feet wide and from 3 feet to 5 feet of brecciated wall rock, cemented with quartz. Values all in gold, both free and in the sulphides.

Development consists of a tunnel driven S. 40° W. about 300 feet. The last 50 feet bears N. 50° W. and in the face has intercepted a 12-inch mineralized streak in dacite; strike N.-S., dip 80° E. and is quite heavily mineralized with iron sulphide. About 50 feet from the face is a raise which apparently went up about 30 feet on a north-south vein, which is about 5 feet wide; 15 inches of quartz and about 4 feet of brecciated wall rocks, all carrying sulphides.

Some 700 feet northwest of this tunnel another tunnel has been driven S. 45° W., 160 feet on a contact of rhyolite and monzonite. This contact is marked by brecciation and clayey gouge, having a width of about 2 feet and is reported to be ore. On this same contact, approximately 300 feet northeast, across a canyon, another tunnel has been driven northeasterly for 80 feet. About 800 feet east and slightly north from this work, a crosscut tunnel has been driven west 460 feet,

The portal of this tunnel is about 200 feet lower than the above described workings. This crosscut was driven to intersect the 'contact vein' at depth. It is reported that the face is still 150 feet from its objective. The tunnel started in a surface rhyolite flow, passed through it in 90 feet into dacite. Strike of the contact is northeast-southwest, dips flatly to the west. It is reported that material on this contact for a width of several feet carries values. No idea of the average values on this property could be formed from available information.

The property was formerly under lease to Ord Belt Mining Company; Claude LeFountaine, president, 2721 Laurel place, South Gate, California. They planned to erect 20-stamp mill, part of which was moved onto the ground but was never erected. Idle except for assessment work.

Oro Grande Gold Mines Company, Geo. Anderson, president; I. H. Anderson, secretary and treasurer, Oro Grande, California. The property consist of 7 claims in the town of Oro Grande, just east of The Atchison, Topeka and Santa Fe Railway line.

The principal vein on this property is in a quartzose, micaceous schist, strike S. 15° E., dip 70° W. A series of narrow northeast-southwest fractures intersect the main fissure. The vein filling is silicified schist, in places consisting entirely of quartz up to 6 feet in width. Just south of the present workings the vein is on the contact of schist, with a dark gray, felsitic rock here having a width of about 4 feet and reported to carry values.

The principal development consists of an open cut about 200 feet long, its depth varying from nothing to 20 feet. In the face, the silicified zone shows a width of 12 feet. In the floor of this open cut there is a shaft, reported to be 120 feet deep. This was inaccessible at the time of visit. It is reported by the operator that all of the material from the open cut was milled in a 10-stamp mill, now on the property, and that it returned $4.50 per ton on the plates. About 200 feet southeast of the face of the open cut, a 30-foot shaft has been sunk on the vein at the contact. It is reported that values were encountered in this shaft.

Idle except for assessment work.

Bibl: State Mineralogist's Reports IX, p. 227; XIII, p. 326; XV, p. 814.

Ophir Mine. The property consists of 4 claims, located 6 miles northeast of Oro Grande. Owners, *Rentchler Mines Company,* Los Angeles; Harvey G. Wolff, president; C. A. DeCoo, secretary.

Development consists of three shafts from 185 to 300 feet in depth.

Bibl: State Mineralogist's Report XIX, p. 173.

Oro Fino Mine. This property is situated in the Silver Mountain District, 10 miles southeast of Victorville. Elevation 3790 feet.

The vein strikes east and west and the country rock is felspathic granite. The vein is from 6 inches to 2 feet wide and carries high values in gold. Idle.

Bibl: State Mineralogist's Report IX, p. 228; XV, p. 815.

Ozark Mine, consisting of 5 claims, is 9 miles northeast of Victorville and about 5 miles from Oro Grande. Elevation approximately 4000 feet. Owners, J. S. and R. E. Garrison, Victorville, California.

The formations exposed on this property consist of rhyolite, quartz porphyry and diorite. The quartz porphyry, which is approximately 100 feet wide, is traversed by a series of stringers, strike N. 35° E. with a vertical dip. The filling in these stringers is talc, quartz and altered wall rock. They appear to follow the natural joints in this rock. The cross joints also are filled with talc and quartz and the two systems form numerous intersections, which, it is reported, are mineralized for the full width of the formation. To a depth of about 60 feet the gold is free; below this point sulphides are encountered. The greatest width of a single stringer observed was 6 inches. It is reported that the quartz in this vein carries $60 per ton.

Development work consists of a vertical shaft 100 feet deep, with levels at 50 and 90 feet, respectively. On the 50-ft. level a drift has been driven southwesterly for some 60 feet. This work was done on two parallel stringers, separated by about one foot of altered wall rock, the whole forming a vein some 2 feet wide, which, it is reported, carries good milling values. Other development work consists of open cuts and shallow holes, one of which it is said yielded some high-grade ore. This pit is in the rhyolite 300 feet southwest of the shaft.

The deposit is essentially a stockwork and should be prospected by a series of crosscuts at a depth of about 100 feet to determine the extent and value of the mineralization. Idle. For early history and further details see,

Bibl: State Mineralogist's Report XV, pp. 813–814.

Painsville Claim was one of the original locations in the Ord Mountain District. This claim, which is patented, is on the west slope of Ord Mountain, 14 miles south of Daggett. It adjoins the Ord Mountain or Osborn Group on the south. Elevation 4500 feet. Owners, I. D. Garringer and J. C. MacMillan, both of Los Angeles.

The ore-bearing zone on the Rio Vista Claim of the Osborn Group also traverses this property. The Rio Vista vein, strike N. 20° W., dip 70° E., occurs in the andesite. This andesite is in contact with monzonite on the west. The dip of the contact, where exposed, is 45° to the west. The actual vein, probably varying from 6 to 10 feet in width, occupies a fissure in the andesite, the mineralization, in places apparently having penetrated the walls for several feet on each side of the fissure. The vein filling consists of quartz and brecciated wall rock, recemented with quartz. Shearing stresses in the vicinity of the veins have produced a schistose structure.

The south half of this property is traversed by a prominent quartz outcrop, strike N. 20° E., dip undetermined. Apparently this vein would form a junction with the Rio Vista about 250 feet south of the 90-foot shaft. This junction, if it exists, is covered by the talus on the mountain side. This is a massive quartz outcrop, in places showing a width of 15 feet or even 20 feet. The east wall is monzonite, which is gneissoid near the vein. The west wall is gneissoid to schistose.

The mineralization of the Rio Vista vein consists of gold and the oxidized ores of copper. Presumably, the quartz vein carries only gold values. No idea of the value per ton has yet been formed.

Development consists of an open cut at the top of a 90-foot shaft about 400 feet south of the north end line. This shaft was inaccessible at the time of visit. The open cut shows a wide zone of silicification and vein about 6 feet in width. The free gold values occur in the broken material on each side of some 3 feet of quartz.

Idle except for assessment work.

Bibl: State Mineralogist's Reports X, p. 528; XV, pp. 808–809.

Piute Mountain Mine. It comprises a group of 10 claims located on the west slope of Piute Mountain, 6 miles southeast of Fenner. Elevation 2800 feet. Owner, Henry Mulheisen and associates, Fenner, California.

The vein occurs in gneissoid granite and consists of a series of lenses of quartz about 20 feet in length and about 4 feet wide, along a fissure at intervals. The strike is northeast and southwest and dip 70° northwest. These lenses of quartz can be followed for a distance of about 500 feet along the outcrop.

Developments consist of a number of open cuts on the different lenses of quartz that are exposed on the surface. The quartz shows free gold, and in 1927 considerable excitement was caused by the discovery of very high-grade gold rock. This caused the location of a great many claims in the district, but the excitement soon died out, due to the fact that no extent of commercial ore was developed. Idle.

Red Bridge Mine. It comprises a group of 9 claims, situated in the Goldstone Mining District, 33 miles north of Barstow. Elevation 3500 feet. Owners, W. B. Redfield and T. L. Henderson, Barstow, California. The claims adjoin the Goldstone Mining Company's group.

Some shipments of high-grade ore were made from the property in 1916, average value being $200 per ton.

Bibl: State Mineralogist's Report XV, pp. 804–807.

Rex and Valencia Hill Group of Mines. It comprises 5 claims, situated in the Holcomb Valley District 42 miles east of Victorville. Elevation 7500 feet. Owner, Rex Mining Company; R. H. Gilman, president, Los Angeles.

The formation is granite, through which intrude large deposits of quartzite, with irregular masses of quartz occurring throughout the quartzite.

On the Rex claim, the quartzite is well defined and outcrops boldly for 1000 feet, having an average width of 250 feet. Free gold occurs in the quartz along fractures. The mass is reported to carry $4 per ton in gold.

Development consists of an incline shaft 100 feet deep and some shallow shafts and open cuts along the outcrop of the vein. Idle.

Bibl: State Mineralogist's Report XVII, p. 350.

Reward Mine. It comprises a group of 5 claims located in the Goldstone District, about 5 miles southeast of Goldstone and 33 miles

north of Barstow. Owner, Walter Sprigg, Goldstone, California. Elevation 4000 feet.

The vein has a width of 2 feet, strikes N. 20° W., and dips 40° W. Development consists of two shafts, 50 and 70 feet in depth. Idle.

Rose Mine. It is situated in the Bear Valley Mining District, in T. 2 N., R. 3 E., S. B. M., 40 miles southeast of Victorville and 5 miles southeast of Dobie.

The formation is limestone, quartzite, mica schist and granite. The vein strikes east and west and dips 45° north. The orebodies are a mixture of quartz and calcite with streaks of hematite. Heavy hematite ore has been shipped from the mine containing from $200 to $500 per ton in gold.

Development consists of an incline shaft 450 feet in depth. It is stated that the shaft passes through the orebody between the 200- and 300-foot levels. The property had a production of $200,000 in gold. Idle.

Bibl: State Mineralogist's Reports XII, p. 234; XV, pp. 795–796.

Shaherald Mining Company has 4 claims, 80 acres, in the Kramer Hills District, 9 miles southeast of Kramer and 26 miles north of Adelanto. Elevation approximately 2700 feet. Owner, Shaherald Mining Company; C. F. Shaw, Jr., president, Fontana, California; T. C. McDonald, secretary, Rialto, California. Under lease to *Kramer Hills Mining Co.,* P. H. Wootton, president, 566 Subway Terminal Building, Los Angeles.

A description of this district has been given in the general remarks under 'Gold' in this report.

The schist belt in which the mineralization occurs has a width on this property of perhaps 200 feet. The strike is east-west, with a low dip (about 30° to 40°) to the south. Several narrow dikes of volcanic rocks have intruded the schist. These probably are connected with several flows which form the hill just north and west of this property. From the amount of brecciation and apparent lack of continuity of these dikes, it is probable that there is considerable faulting here but there is not sufficient underground work to definitely determine its extent. However, within a few feet of the surface the formation has been faulted along an east-west line with a throw of a few feet to the north.

Gold values are distributed throughout the schist belt to the depths prospected on this property, but the distribution is far from being uniform. Along the contacts of the narrow dikes with the schist, in the dike rock itself, in the brecciated material which frequently accompanies the dikes and in veins wholly within the schist (which are never far removed from the dikes), high-grade spots and small pockets are encountered. The veins proper, to depths yet explored, are filled with talc. When the talc contains quartz grains, gold is also present, some of it being very rich. The dike rock, which is highly stained with iron and manganese compounds, also carries gold, in places quite rich. This gold is always fine and 'rusty.' The brecciated material, which consists of schist fragments and, largely, clay, carries gold when the granulated quartz is present. Gold also occurs in the joints developed in the schist itself.

Much sampling has been done on this property in an attempt to determine the average values. Most of these samples come from the workings of an incline shaft. This shaft was sunk on an inclination of about 35° for a distance of 60 feet. Approximately 400 feet of drifts and crosscuts were driven on two levels which are only 15 feet (vertically) apart. These workings are connected with a 65-foot vertical shaft, by means of a 25-foot winze and a 65-foot crosscut. This vertical shaft is south of the incline shaft and was sunk wholly within the schist. Samples cut at 5-foot intervals in the crosscut showed average values of $4.50 per ton, $8 being the upper limit and $2 the lower. Just opposite the winze, which is 50 feet southeast of the shaft, a raise was driven which practically connects with the bottom of a shallow shaft. There is a vertical shaft 100 feet deep two 50-foot vertical and one 75-foot vertical shaft, in addition to numerous open cuts and shallow pits on the property. A systematic sampling of the workings of the incline shaft, including the 75-foot vertical shaft and crosscut, gave an averafe value of $3.50 after elimination of all assays which ran $10 or over. It was found that 12% of the samples showed values greater than $10. These were all eliminated. This average was further confirmed by the milling of approximately 100 tons, from which $1.55 per ton was recovered on the plates. The tailings ran $1.75. The low recovery by amalgamation was largely due to the sticky talc and to the 'rusty' and very fine gold in the ore.

Later the leasing company erected a mill which is arranged as follows: Ore is delivered to an Irving crusher by a dragline, crushed to ½″, thence by incline conveyor to the mill building where it is screened to 14 mesh, oversize to waste, screenings to bin; thence to Dorr Simplex classifier in closed circuit with Hardinge mill. Overflow to 6 Kraut flotation cells. After mining some 3200 tons, of which about 700 tons went through the mill, this plant was shut down, presumably because it was found that the values in the reject were too great. Idle.

Sidewinder Mine is 13 miles east of Victorville, in the Highland Mountain, at an elevation of 3800 feet. Owner, the *Armstrong Mining Company*; W. B. Armstrong, president; J. J. Sammett, secretary, Hollywood, California.

This property, now consisting of 4 claims, was first opened some 45 years ago. As early as 1889 there was a 100-foot shaft, with an 80-foot drift and open cuts on the property. In 1887 a 10-stamp mill was erected at Victor (now Victorville) to treat the Sidewinder ore, which was reported at that time to yield $30 per ton in free gold.

The rocks of this mountain are essentially granitic, with possibly some thin beds of limestone. The vein, strike NW.-SE., locally shows a schistose to slaty hanging wall and a syenitic footwall. The dip is to the west, varying from 35° to 45°. It is traceable across the property for about 3000 feet.

A crosscut tunnel was driven southerly and is known as the 200-foot level. From where it intersects the vein, drifts have been driven NW. and SE. An old shaft passes through this level and 200 feet below, with development and some stoping on two levels below the tunnel. This inclined shaft 400 feet deep has about 1000 feet of drifts on the first level, 1300 feet on the second or tunnel level and over 400 feet

on the third level and 300 feet on the fourth level; also a 200-foot shaft on the Keyholes Claim, with 500 feet of drifts and some stoping. There are reported to be four other shafts on this property, averaging 200 feet in depth.

Present work consists of sinking a new shaft started from the tunnel level, at a distance of about 500 feet southeast of the old shaft. Part of this shaft was made by timbering-in an old stope. In November, 1929, it was down to the 508-foot level. A station was to be cut at 510 feet and shaft carried down to an undetermined depth. Also a new haulage tunnel 700 feet long had been driven from the new shaft to the outside. On account of the shaft timbering, the vein was only visible in the bottom. Here it showed a width of about 5 feet in 3 sections. The center section, 2½ feet wide, is talcose schist, carrying pyrite. On each side is 1 to 1½ feet of iron-stained quartz. No idea of the average values could be obtained but previous operations would indicate from $6 to $7 per ton.

An underground electric hoist has been installed to serve the new shaft. A cyanide mill was erected here in 1927–28. Water for the mill is hauled from the company's well 5 miles away. Power is supplied by the Southern Sierras Power Company, a line having been brought from Victorville.

Mill equipment consists of Baash-Ross jaw crusher (200-ton capacity); conveyor to crushed ore bin; 4-foot by 6-foot Marcy-type mill; Dorr classifier in closed circuit with 5-foot by 16-foot tube mill; 24-foot Dorr thickener; 2 Devereaux agitators; American filter; Butters filter for clarifying pregnant solution; zinc dust precipitation. There is also a Grotch flotation machine, presumably installed to handle lead ore from a parallel vein on the property. All machines have individual motor drives.

At the time of visit 16 men were employed sinking the shaft and making changes at the mill.

Bibl: State Mineralogist's Reports IX, p. 227; X, pp. 527–528; XII, p. 235; XIII, p. 328.

Silver Dome Mine, consisting of 10 lode and 8 limestone placer claims, is in the Fremont Peak District, in Sec. 32, T. 12 N., R. 42 E., M. D. M., about 20 miles southeast of Randsburg. Elevation 2450 feet. Owner, Silver Dome Mining Company; Capt. A. Rolling, president; Fred Knappen, secretary. Offices, formerly in Wright-Callender Building, Los Angeles.

This property is in the low, rolling hills just west of Fremont Peak. It was discovered in 1920 and taken over by the above company in 1922.

A series of 4 parallel fault fractures occur in the granite. The principal vein, on which the development work has been done, is accompanied by a diabase dike, the vein being on the hanging wall side of the dike. The average width is 4 feet with a maximum of 8 feet. It has been proved on the surface for a length of 4500 feet. The vein filling consists of quartz and calcite with enclosed wall rock. Mineralization includes chalcopyrite, pyrite and bornite, with values in gold and silver.

Developments consist of a shaft sunk on an incline of 45° to 200 feet and about 85° to 250 feet, a total depth of 450 feet. At 150-foot level, there is a drift 15 feet west; on the 265-foot level, a drift 114 feet east, with 15 feet of a crosscut south 56 feet from the shaft; also drift 50 feet west of shaft. High-grade spots were encountered in this work and it is reported that values on the 265-foot level would average 3 to 12% copper, $7 to $20 gold and 7 to 15 ounces of silver.

Equipment consisted of 25-h.p. Western gas engine hoist; two 9 inch by 14 inch Chicago pneumatic compressors direct connected to 'hot head' engines; a No. 5 Cameron pump; cars; blacksmith shop; and dwellings.

Idle except for assessment work.

Southern Cross (formerly the *Little Annie*), consisting of one claim, is in the Silver Mountain District, about 6 miles east of Oro Grande. Elevation about 3500 feet. Owners, Mark Low and Sam Weed, Victorville, California.

Quartz vein in rhyolite, up to 6 feet in width. Strike N. 45° E., dip 30° SE.

Development consists of three shafts, having reported depths of 50 feet, 100 feet, and 50 feet, on the vein, respectively. It is reported that there is a drift 200 feet southwest at the bottom of the 150-foot shaft and that the vein at this depth shows a width of 3 feet and will pan gold. Some ore was milled at Victorville several years ago with a reported production of $2,000.

Idle except for assessment work.

St. Elmo Mine. It comprises 6 patented lode claims situated in the Atolia Mining District, one-half mile south of Atolia and 5 miles south of Randsburg. Owner, Thomas R. Hanna, Martinez, California. Elevation 3400 feet.

Two well-defined veins occur in quartz-monzonite, strike N. 30° E., dip 80° NW., and N. 40° E., dip 80° NE. The widths of these two veins vary from 4 to 10 feet. The veins are 325 feet apart at the shaft and are connected by a crosscut on the 250-foot level. There is a possibility that about 458 feet south of the shaft these veins will converge. On the west vein there is a vertical shaft 250 feet in depth, with drifts on the 100-foot, 150-foot and 250-foot levels. For a distance of 200 feet south of the shaft the vein has been stoped from the 150-foot level to the surface. On the last vein there is a shaft 150 feet deep and also open cuts and shallow shafts along the vein outcrop. The vein has a width of 4 to 8 feet. The vein has been stoped to the surface for a distance of 300 feet above the 100-foot level.

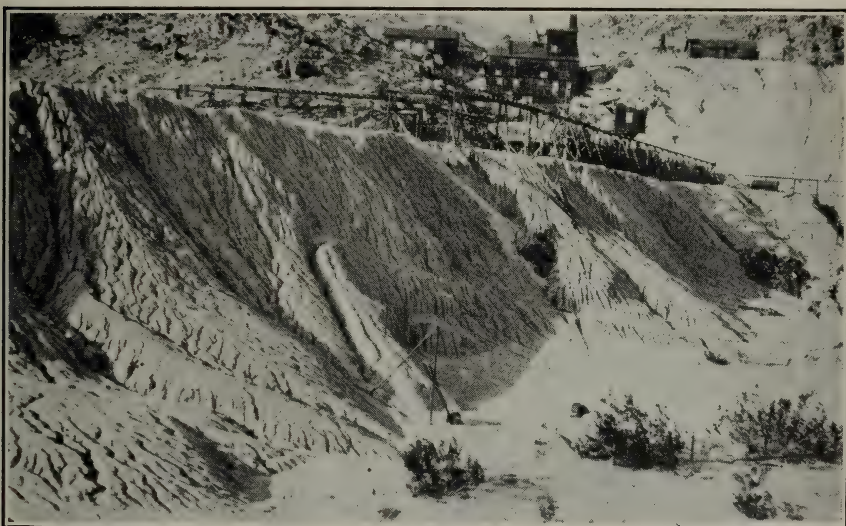
The mine was discovered in the late nineties and the production from 1897 to 1898 was $140,000. The ore shipped from the property to the Selby Smelting Company netted $350 per ton. Idle.

Supply Mine. It comprises 9 patented claims situated in the Dale Mining District, in Sec. 35, T. 1 N., R. 11 E., S. B. M., on the west slope of the Dale Hills, 15 miles east of Twenty-nine Palms. Elevation 2350 feet. Owners, Seely Mudd Estate and Philip Wiseman, Los Angeles.

This property is the most important mine in the Dale Mining District and for many years was a regular producer, having yielded

over \$500,000. The formation is andesitic porphyry. There are two veins known as the Supply and Jean. The veins strike north and south and dip 70° east. The widths of the veins vary from 4 to 10 feet. The Supply and Jean veins are about 1000 feet apart. The vein material is iron-stained quartz, showing considerable hematite, also copper stained. The ore mined and milled is said to have had an average value of \$9 per ton. The Supply vein was developed by a shaft 1250 feet deep, sunk on an incline of 70°, with levels at 100-foot intervals. There are over 5000 feet of underground workings on the vein. The development on the Jean vein consists of an incline shaft about 200 feet in depth.

The ore was treated by dry crushing and direct cyanidation. The capacity of the mill was 100 tons per 24 hours. The mine was operated steadily until 1915 and in 1928 was reopened and operated under lease



One hundred ton mill and tailings dumps. Supply Mine, Dale Mining District, San Bernardino County.

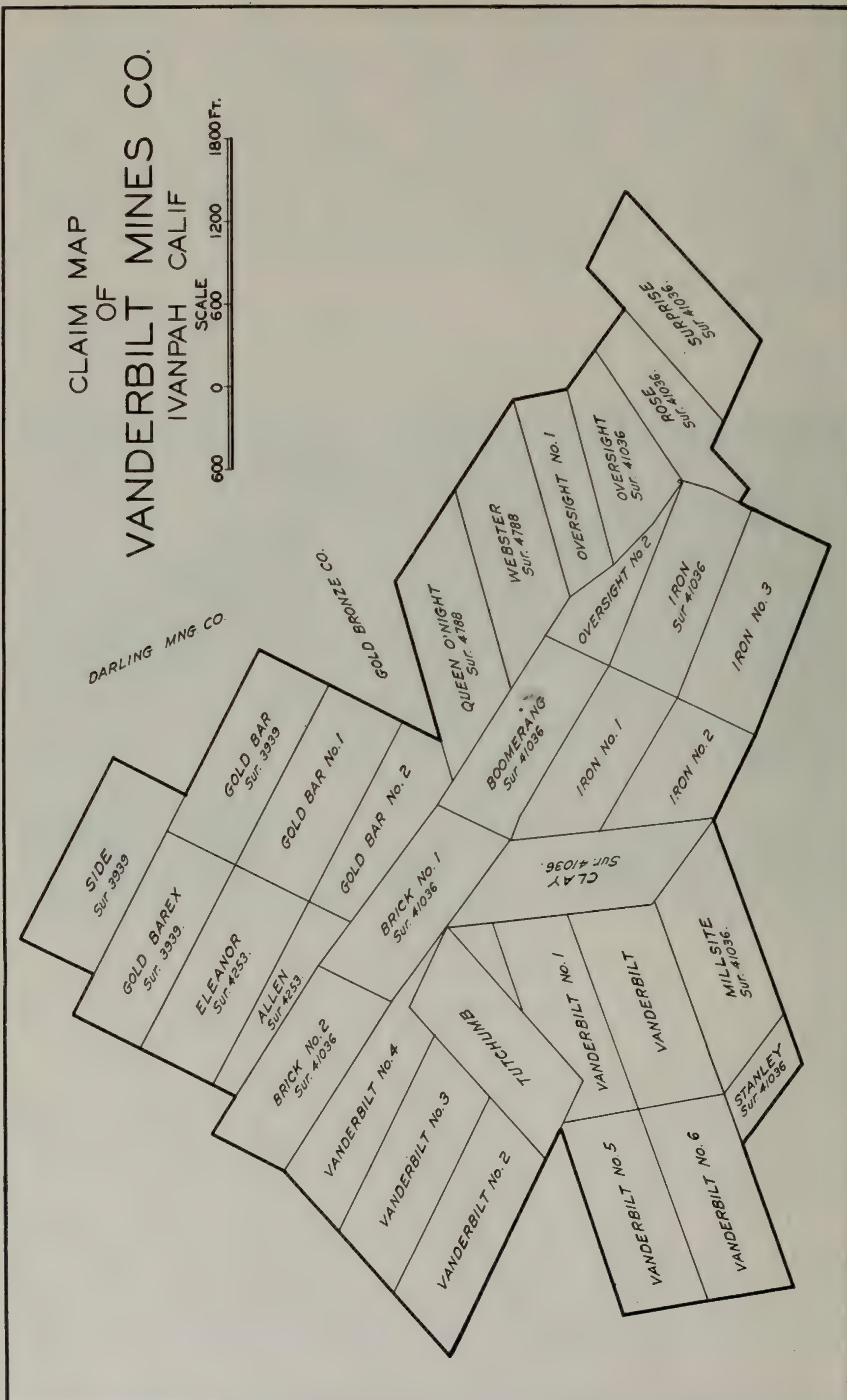
and bond by the *Arrowhead Development Company,* of Nevada, for a short time. Idle.

Bibl: State Mineralogist's Report XV, p. 802.

Tillie Rand Mine. It comprises 11 claims located in the Fremont Peak Mining District, on the east slope of Fremont Peak, 20 miles southeast of Randsburg. Owner, Tillie Rand Mining Company; A. C. Schurmer, president, Los Angeles.

A series of parallel veins in hornblende granite; strike north and south and dip steeply to the west. The veins vary in width from 2 to 4 feet. The principal development has been confined to a shear zone in the granite. The total width of the vein that follows this shear zone is 4 feet, with 2 feet of quartz. The other vein material is decomposed granite on the footwall and granite-porphyry on the hanging wall.

Development consists of a shaft about 200 feet deep and a number of shallow shafts and open cuts on the different veins. Idle.


CLAIM MAP
OF
VANDERBILT MINES CO.
IVANPAH CALIF
SCALE
600
0
600
1200
1800 FT.
DARLING MNG. CO.
GOLD BRONZE CO.
SIDE Sur 3939
GOLD BAREX Sur. 3939.
GOLD BAR Sur. 3939
GOLD BAR No. 1
GOLD BAR No. 2
ELEANOR Sur. 4253.
ALLEN Sur 4253.
BRICK No. 1 Sur. 41036
BRICK No. 2 Sur. 41036
QUEEN O'NIGHT Sur. 4788
WEBSTER Sur. 4788
OVERSIGHT No. 1
OVERSIGHT Sur. 41036
OVERSIGHT No 2
ROSE Sur. 41036.
SURPRISE Sur. 41036.
BOOMERANG Sur. 41036
IRON Sur. 41036
IRON No. 1
IRON No. 2
IRON No. 3
CLAY Sur. 41036.
VANDERBILT No. 4
VANDERBILT No. 3
VANDERBILT No. 2
TUTCHUMB
VANDERBILT No. 1
VANDERBILT
MILLSITE Sur. 41036.
STANLEY Sur. 41036
VANDERBILT No. 5
VANDERBILT No. 6

U. S. Group of 4 claims is in the Von Triger District, 14 miles north of Goffs. Owners, S. A. and George W. Golden, Daggett, California.

It is reported that a porphyritic dike 12 feet in width, strike east-west, dip 45° south, is traversed by numerous quartz stringers, samples from which assay from $3.50 to $100 per ton.

Development consists of an incline shaft 30 feet deep.

Idle except for assessment work.

Vanderbilt Mines, comprises a group of 38 claims, of which 18 claims are patented, situated in the Vanderbilt Mining District, on the west slope of the New York range of mountains, 4 miles east of Ivanpah, a station on the Union Pacific Railroad. Elevation 5000 feet. Owner, Vanderbilt Mining Company, Allen G. Campbell Estate, of Riverside, California. Under option to the *Reorganized Silver King Divide Mining Company*; Schad Smith, president; H. G. Humes, vice president and general manager; H. W. Smith, secretary; I. S. Hardester, superintendent. Offices, 434 I. W. Hellman Building, Los Angeles.

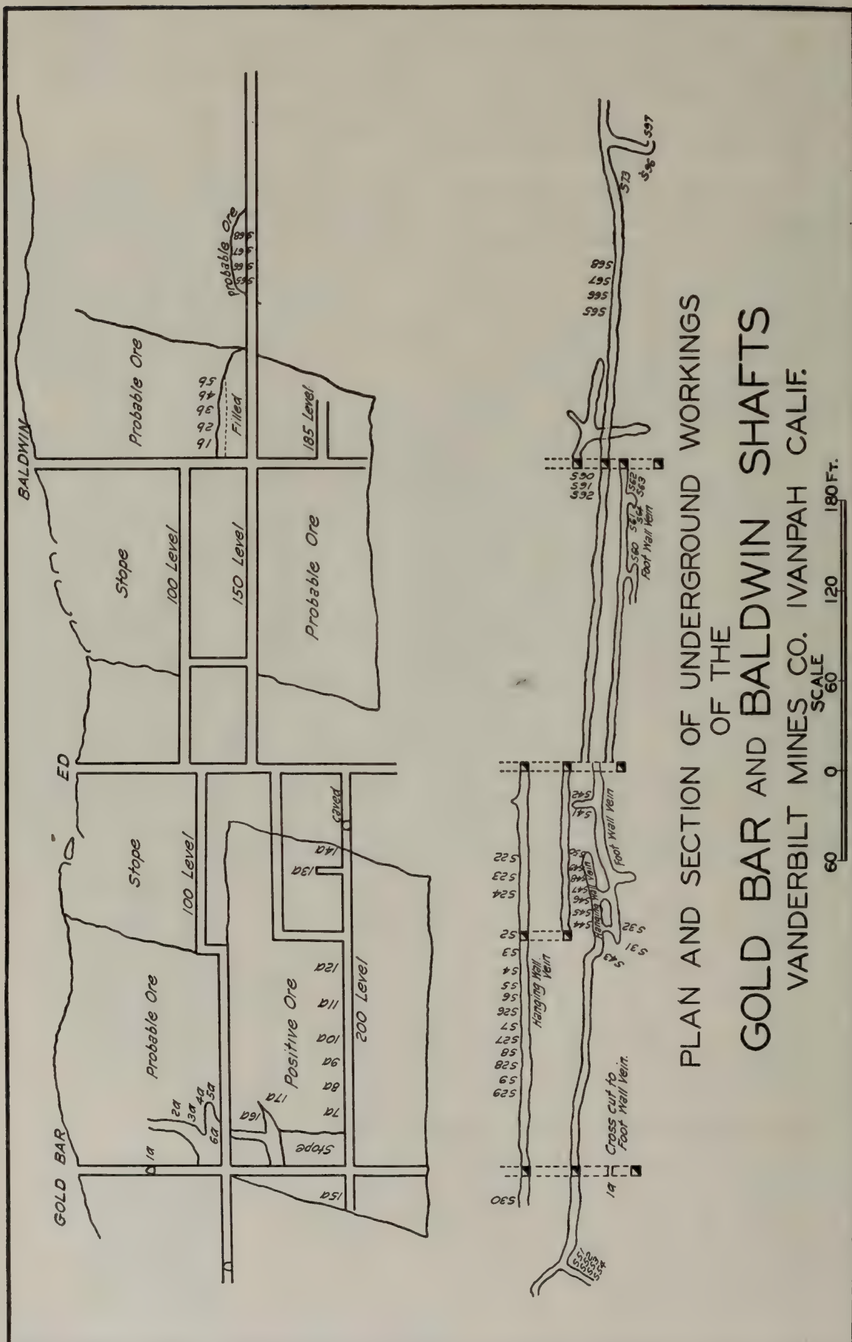
The rocks of the district are chiefly gneissoid and schistose, granitic and hornblende rocks, intruded by pegmatite dikes. A series of parallel veins occur in granite, strike N. 70° W., dip 60° to 70° N. The most important veins are the Gold Bar and the Boomerang veins, which are about one-half mile apart. The Gold Bar vein system consists of a hanging wall and footwall vein, which are about 20 feet apart. These veins are separated by quartz-porphyry, and the walls are an altered granite. The oxidization extends from the surface to a depth of 150 feet, where sulphide ore was encountered. The vein quartz in the oxidized zone is heavily mineralized with hematite. The vein quartz below the 150-foot level is mineralized with pyrite, marcasite, galena and chalcopyrite. Sixteen cars (50 tons each) of ore mined from the 150-foot level of the Gold Bar shaft and shipped to the International Smelter at Salt Lake, Utah, averaged $20 per ton in gold and silver. The general grade of ore that has been developed on the property that has been determined by careful sampling, is as follows:

Gold	0.62 ounces
Silver	3.74 ounces
Lead	0.70 per cent
Copper	0.51 per cent
Insoluble	71.60 per cent
Iron	7.80 per cent
Sulphur	4.70 per cent
Lime	2.20 per cent

The average value of ore shipments were as follows:

Gold	0.72 ounces
Silver	3.50 ounces
Copper	0.50 per cent
Lead	0.80 per cent
Iron	8.00 per cent
Silica	74.00 per cent

The Gold Bar lode has been developed by three shafts known as the Gold Bar, Ed and Baldwin. The Baldwin shaft is the most westerly shaft on the vein, being 270 feet west of the Ed shaft, which is 230



PLAN AND SECTION OF UNDERGROUND WORKINGS
OF THE
GOLD BAR AND BALDWIN SHAFTS
VANDERBILT MINES CO. IVANPAH CALIF.

feet west of the Baldwin shaft. The Gold Bar shaft is 425 feet deep, sunk on an incline of 60°. The Ed shaft is 400 feet deep on the vein. The Baldwin shaft has been sunk on the vein to a depth of 300 feet. The ore developed on the 200-foot level is 250 feet in length, with an average width of 8 feet. The average value is said to be $20 per ton in gold and silver.

Development on Gold Bar Vein: The Baldwin shaft is sunk on the hanging wall vein, with crosscuts on the different levels to the foot-wall vein, and the ore developed on the latter vein is said to contain the highest values. On the 100-foot level, the Gold Bar shaft connects with the Ed shaft and is driven 100 feet east of Ed shaft. Ore is stoped from 100-foot level to the surface. On the 200-foot level of the Gold Bar shaft there is a drift east 250 feet, drift west 25 feet. The Boomerang shaft has been sunk on the Boomerang vein system to a depth of 565 feet. This vein system consists of two parallel veins about 100 feet apart. The average width of this vein is 8 feet and it is said the average value is $20 per ton in gold and silver.

On the 100-foot level drift east 260 feet and west 230 feet.

On the 200-foot level drift west 140 feet and east 80 feet.

On the 300-foot level drift 165 feet east.

On the 400-foot level drift 60 feet west and east 55 feet. On 400-foot level about 25 feet west of shaft there is a crosscut north 50 feet.

On the 500-foot level drift east 110 feet and west 40 feet.

The ore shoot developed and stoped on the 100-foot level was 250 feet in length, with an average width of 8 feet.

Mine equipment consists of 15-h.p. Fairbanks-Morse hoist at Baldwin shaft, 22-h.p. hoist at Gold Bar shaft; and Ingersoll-Rand 9-inch by 8-inch compressor.

This company is unwatering the Gold Bar and Baldwin shafts, also retimbering the underground workings. It is planned to unwater the Boomerang shaft and retimber the underground workings. Mill tests are being made on the ore from the Gold Bar workings to determine the best method of treatment. Flotation tests so far made indicate a recovery of 96% of the gold and silver values. Eight men are employed.

Bibl: State Mineralogist's Reports XI, pp. 367–368; XII, pp. 235–237; XIII, p. 329; XV, p. 816.

Virginia Dale Mine. It comprises 6 claims with 6000 feet on the lode, situated in the Dale Mining District, in Sec. 29, T. 1 N., R. 12 E., S. B. M., 18 miles east of Twenty-nine Palms. Elevation 2000 feet. Owner, Virginia Dale Mining Company; Judge J. A. Reese, president; A. D. Blehm, secretary, San Bernardino, California.

Three parallel veins occur in quartz-diorite and are about 150 feet apart. These veins strike N. 20° W. and dip from 70° to 80° E. The veins vary from 4 to 6 feet in width. The main development is confined to the Middle vein. The vein quartz is iron stained, being mineralized with hematite, magnetite and manganese. The values vary from $9 to $20 per ton in gold, average value being $12 per ton.

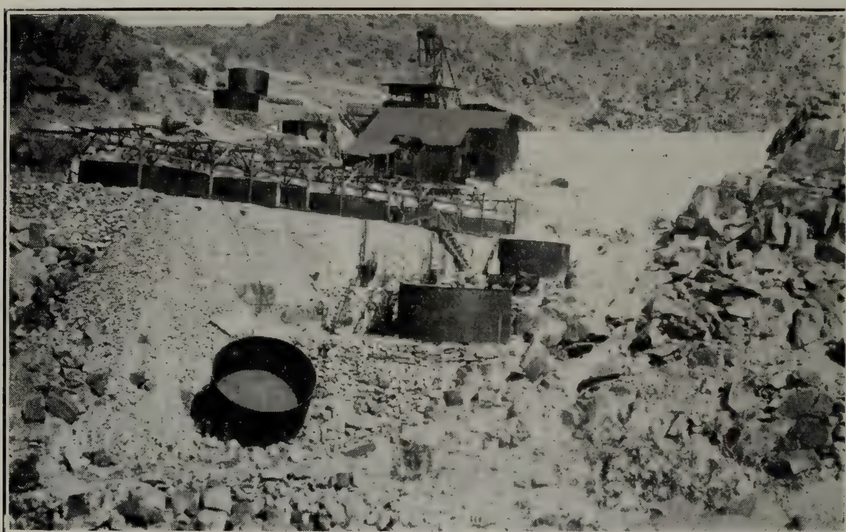
Development consists of a shaft 350 feet in depth sunk on an incline of 70°.

On 100-foot level drift north 350 feet and south 300 feet.

On 200-foot level drift south 300 feet and north 300 feet.

Three ore shoots have been developed in the form of lenses of quartz in the fissure. These shoots vary from 50 to 100 feet in length, with an average width of 4 feet.

Mine equipment consists of 15-h.p. gas-engine hoist. Mill equipment consists of 8-inch by 10-inch Blake crusher; National crusher mill, where ground to 20-mesh, the pulp from ball mill passing over amalgamation plates then to cyanide plant. Reported recovery is said to be 90%. Mill has a capacity of 40 tons per 24 hours. The plant is driven by a 25-h.p. West Coast gas engine. The water supply is secured from a well at Old Dale, about 5 miles northwest of the mine. Water is pumped through 2-inch pipeline to storage tanks having a capacity of 35,000 gallons.



Headframe and 50-ton mill. Virginia Dale Mine, Dale Mining District, San Bernardino County.

The mine has been operated off and on since 1896. Last operations were in 1928 and 1929 and it is said that the company intends to resume operations in the very near future. Six men are employed in remodeling mill and building new bunkhouse.

Wanderer Mine. It comprises 15 claims situated 5 miles north of Halloran Springs, in T. 10 N., R. 10 E., S. B. M., in Halloran Springs Mining District. Owner, James Hyten, San Bernardino, California. Under option to *American Hellenic Gold Mining Co.,* Las Vegas, Nevada; James McCoy, president. Two parallel quartz veins occur in granite, strike N. 30° E., dip 80° E. Widths 2 to 4 feet. The quartz is heavily iron stained, shows free gold in hemitite. Development consists of a number of shafts sunk along outcrops for distance of 4000 feet to depths of 50 to 150 feet. Main shaft, 125 feet deep. Near main shaft the veins are 50 feet apart, but 1000 feet north of shaft the veins intersect. Ore is reported to carry from $10 to $20 per ton in gold.

Equipment consists of 12-h.p. gas-engine hoist, Gardner compressor. Mill has capacity of 20 tons per 24 hours. Four men employed.

White Nugget Group of Placer Claims. This group of 4 claims is situated at Coolgardie in the SE¼ of Sec. 24, T. 32 S., R. 1 W., S. B. M., 15 miles north of Barstow. Owners, A. J. Rearkrant and Earl Rose, Pasadena, California.

The gravel is worked by means of dry washers and is said to carry values varying from 50 cents to $2 per cubic yard. Idle.

Winchester Group of Claims. This group comprises 5 claims, situated in the Arrow Mining District, on the east slope of Providence range of mountains, 20 miles west of Fenner, a station on the Santa Fe Railroad. Owner, George Kinney, Avalon, Catalina Island. The claims adjoin the Hidden Hill group of mines.

A series of parallel veins in granite porphyry, strike N. and S., dip 45° W. Widths vary from 12 inches to 2 feet. Developments consist of tunnels and shafts. Idle.

Yankee Maid Mine. It comprises 6 claims located 8 miles north of Oro Grande, a station on the Santa Fe Railroad. Elevation 4000 feet. Owner, *Golden King Mining and Milling Company,* Victorville.

The vein occurs in granite. Development consists of two shafts 100 and 140 feet in depth. Formerly operated by the *Yankee Maid Mining and Milling Company,* of Victorville, California. Idle.

Bibl: State Mineralogist's Report XV, p. 814.

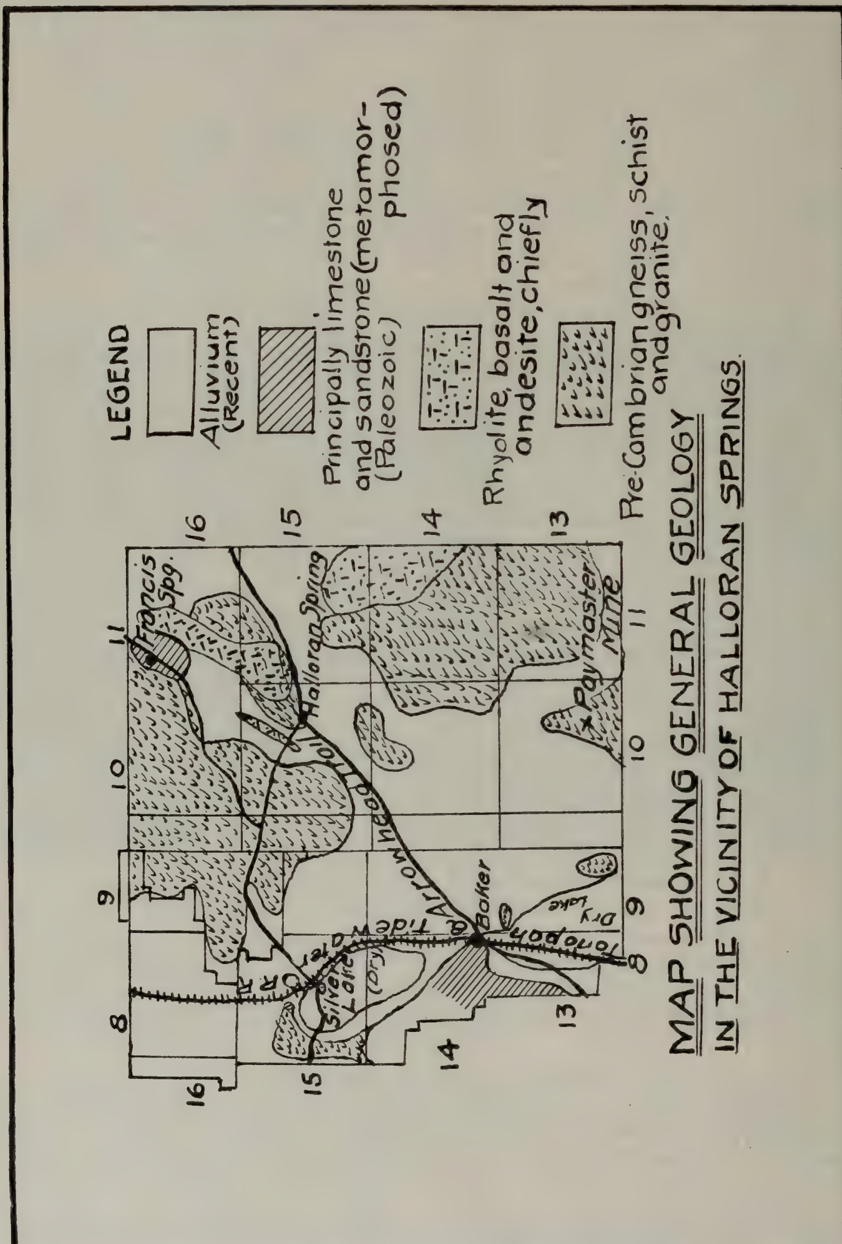
HALLORAN SPRINGS MINING DISTRICT

By W. B. Tucker

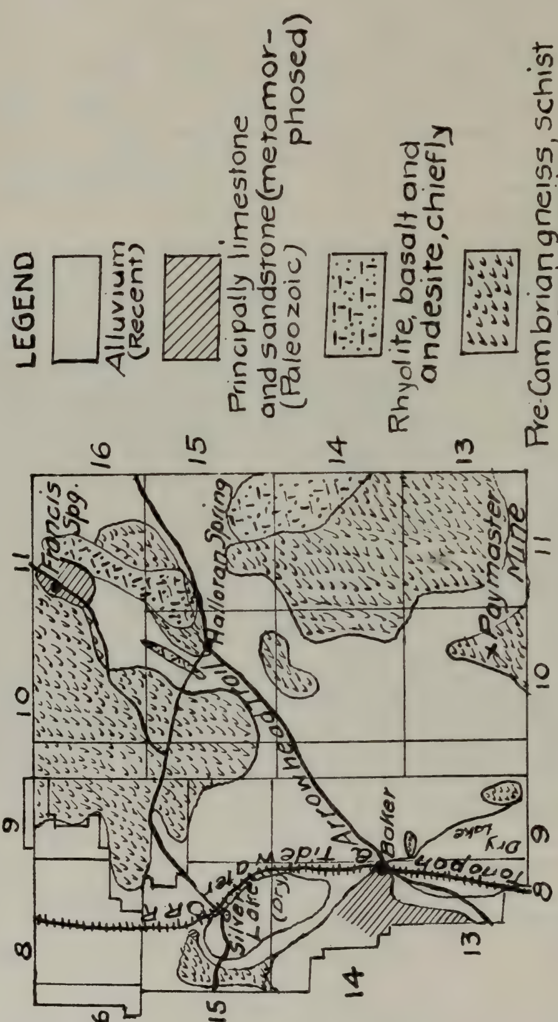
The Halloran Springs District is situated in Mojave Desert region, 12 miles east of Baker, a station on the Tonopah and Tidewater railroad, and the Arrowhead highway from Los Angeles to Las Vegas runs through the center of the district. The elevation of Halloran Springs is 3440 feet; Yucca Grove near its east limits has an elevation of 4000 feet. The Paymaster Mine which is located near the southern area of the mineral belt has an elevation of 2100 feet. The district is located in what was formerly known as the Solo Mining District. The approximate boundaries extend east of Soda Lake to the Paymaster Mine and Indian Creek, then north to the old Turquoise Mines, in the Turquoise Mountains, situated in the southern part of T. 16 N., R. 10 and 11 E., S. B. M.

The principal mineralization is confined to Tps. 13, 14 and 15 N., R. 10 and 11 E., and can be described as extending 15 miles north of the Paymaster Mine to the Turquoise Mines and about 12 miles from east to west; the Wanderer Mine being the most westerly limits of the district.

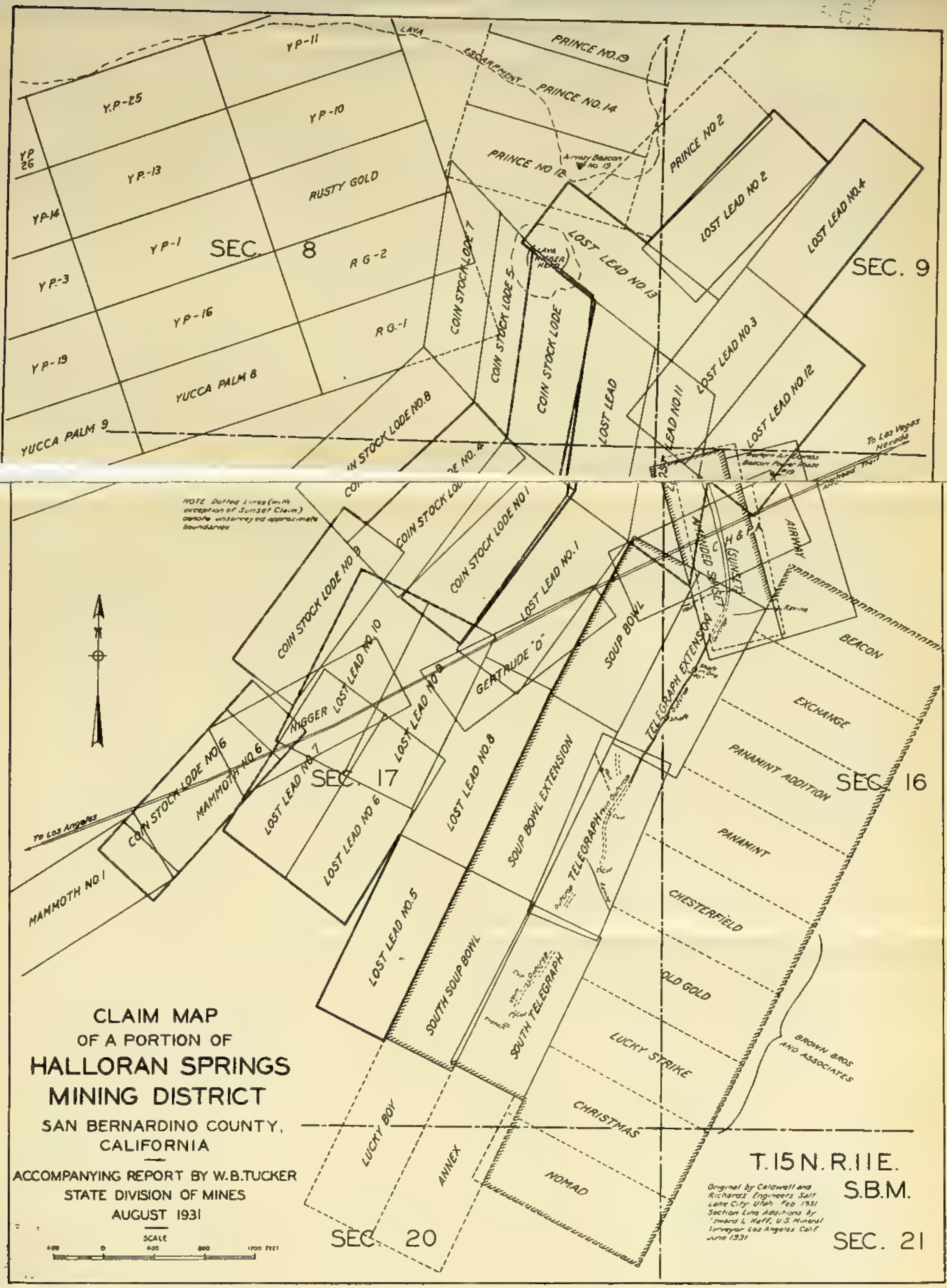
Acknowledgments. The writer desires to express his obligations to the following individuals who were of assistance in furnishing information on the mineral resources of the district: Messrs. Vivian Burns, Robert Burns, and Mr. Ingersoll, of the Arrowhead Gold Mining Company; C. W. Coyle, of Halloran Springs; A. A. Brown and Ralph



MAP SHOWING GENERAL GEOLOGY IN THE VICINITY OF HALLORAN SPRINGS.



MAP SHOWING GENERAL GEOLOGY IN THE VICINITY OF HALLORAN SPRINGS


CLAIM MAP
OF A PORTION OF
HALLORAN SPRINGS
MINING DISTRICT
SAN BERNARDINO COUNTY,
CALIFORNIA
ACCOMPANYING REPORT BY W.B.TUCKER
STATE DIVISION OF MINES
AUGUST 1931
SCALE
T.15 N. R.11 E.
S.B.M.
SEC. 8
SEC. 9
SEC. 16
SEC. 17
SEC. 20
SEC. 21
LAVA ESCARPMENT
PRINCE NO.13
PRINCE NO.14
PRINCE NO.12
PRINCE NO.2
Airway Beacon No. 13
Y.P.-11
Y.P.-25
Y.P.-10
YP 26
Y.P.-13
Y.P.-14
RUSTY GOLD
Y.P.-1
Y.P.-3
RG-2
Y.P.-16
RG.-1
Y.P.-19
YUCCA PALM 8
YUCCA PALM 9
COIN STOCK LODE 7
COIN STOCK LODE 5
COIN STOCK LODE
COIN STOCK LODE NO.8
COIN STOCK LODE NO.1
COIN STOCK LODE NO.9
COIN STOCK LODE NO.6
LOST LEAD NO.13
LOST LEAD NO.2
LOST LEAD NO.4
LOST LEAD NO.3
LOST LEAD NO.12
LOST LEAD NO.11
LOST LEAD
LOST LEAD NO.1
LOST LEAD NO.10
LOST LEAD NO.9
LOST LEAD NO.8
LOST LEAD NO.7
LOST LEAD NO.6
LOST LEAD NO.5
To Las Vegas Nevada
Arrowhead Trail
To Los Angeles
NOTE Dotted Lines (with exception of Sunset Claim) denote unsurveyed approximate boundaries
C.H. & P.
SUNSET
AIRWAY
SOUP BOWL
GERTRUDE "D"
NIGGER
MAMMOTH NO.6
MAMMOTH NO.1
TELEGRAPH EXTENSION
TELEGRAPH
SOUP BOWL EXTENSION
SOUTH SOUP BOWL
SOUTH TELEGRAPH
BEACON
EXCHANGE
PANAMINT ADDITION
PANAMINT
CHESTERFIELD
OLD GOLD
LUCKY STRIKE
CHRISTMAS
NOMAD
LUCKY BOY
ANNEX
BROWN BROS AND ASSOCIATES
Ravine
Shaft
Original by Caldwell and Richards Engineers Salt Lake City Utah Feb 1931 Section Line Additions by Edward L Hoff, U.S. Mineral Surveyor Los Angeles Calif June 1931

Brown, of Telegraph Group of Claims; John Herrod, of Paymaster Mines; and Mr. Gilmore, of Halloran Springs.

PHYSICAL FEATURES OF THIS AREA

There is a long slope that rises more or less continuously from Soda Lake and Silver Lake valleys eastward for many miles. This high land area, a sort of plateau with a slight westward slope, is separated from the alluvial slopes in the lowest part of the area by a more abrupt slope in the eastern part of Tps. 13 and 14 N., R. 10 E., and all of Tps. 13 and 14 N., R. 11 E.

In the southeasterly part of T. 15 N., R. 11 E. and the northeastern part of T. 14 N., R. 11 E., there is a nearly flat area, with steep slopes descending on the northwest and west, but with a more gradual ascent on the east. From the Arrowhead highway several miles north of the flat area appears to be a lava flow similiar to the one lying just north of the highway. The long, gradual slope rising to an altitude of 4800 feet above the bottom of the valley, has the appearance of an alluvial slope, but granite at a depth of only a few feet in mine shafts and small outcrops show that in many places the alluvium is at best very thin.

Several more or less isolated mountain ridges are seen east of Soda Lake. These have a northerly or slightly northwesterly trend and are rather narrow. One high mountain ridge, situated east of the Paymaster Mine, trends northerly to the Turquois Mountains, and is paralleled by smaller ridges to the west and northwest.

Geology. (See Map)

In T. 15 N., R. 11 E. to the north of the highway between Halloran Springs and Yucca Grove and extending east several miles, Tertiary volcanic rocks rest upon granitic rocks. The rocks of the Turquoise Mountains are mainly granitic, but at several places there are areas of Tertiary volcanic rock.

The most notable of such areas is in the northwest corner of T. 15 N., R. 11 E., where a basaltic flow overlies the granite and slopes gently southwestward. This is seen from the Arrowhead highway between Halloran Springs and Yucca Grove. The area south of the highway is made up entirely of Pre-Cambrian granite, with occasionally isolated peaks covered with Tertiary volcanic rocks, such as Black Mountain. In the vicinity of the Paymaster Mine in T. 13 N., R. 10 E., the granitic rocks are overlain by a series of quartzites and limestones of the Cambrian age.

In the Halloran wash, about 2 miles west of Halloran Springs, in T. 15 N., R. 10 E., there is a belt of andesite about two miles in length and 1000 feet in thickness that has a general northerly course and dips steeply to the west.

Vein System.

In the area near Halloran Springs a series of roughly parallel calcite-quartz veins occur in the granite and strike N. 30° to 50° E., with dips varying 40° to 60° to the northwest. The width of the veins vary from 12 inches to 6 feet. Some of the calcite-quartz veins occur along

aplite dikes that strike from N. 30° to 70° E. These dikes vary in width from 20 to 50 feet and can be traced for a considerable distance along their strike. In the vicinity of the Paymaster Mine the veins are principally quartz that occur in the granite, also in a number of instances, cut the overlying quartzite. The quartz veins vary in width from 12 inches to 6 feet. The vein quartz is heavily iron stained, containing hematite, pyrite and some chalcopyrite. The general strike of the Paymaster system of veins is N. 30° E.

History.

The first discovery of gold in the Halloran Springs District was made about 1900. Considerable prospecting and some development were carried on until about 1914.

The district lay dormant until November 19, 1930, when A. A. Brown and Ralph Brown, of Salina, Utah, discovered some high-grade gold quartz on what is now known as the Telegraph vein. It is reported that one sample cut from this vein showed free gold in calcite and quartz and assayed $800 per ton in gold. They returned to Utah and interested Vivian and Robert Burns, of Salina, Utah, who located a large number of claims in the district. These locations caused a revival of interest in this area and a large number of claims have been filed upon and recorded.

The Burns brothers interested Mr. George W. Snyder, of Salt Lake, in their claims and the Arrowhead Gold Mining Company was organized. This company acquired the claims of the Burns brothers and started active prospecting and development work on the most important veins. The results obtained in this development campaign were encouraging and the possibilities look favorable for the development of several producing properties.

In the vicinity of the Paymaster Mine considerable excitement was caused by the discovery of high grade gold quartz by M. A. Sisley and John Herrod, on the Brannigan Claims, which were located March 11, 1930. They extracted 16 tons of ore which was milled at the Wanderer mill and it is stated they recovered $100 per ton on the plates, with a loss of $65 per ton in tailings. This also caused a revival of interest in this area and a large number of claims have been located in the vicinity of the Paymaster Mine.

The major development is being done by the Arrowhead Gold Mining Company, of Salt Lake City, Utah; Death Valley Mines Company, of Utah; and the Brown brothers.

Power and Water.

The California-Nevada Power Company's transmission line crosses the Halloran Springs Mining District. Water for domestic needs is secured from Halloran Springs. Recently water has been encountered in the Gold Pin and Lost Lead shafts which will insure sufficient water for mining and milling operations.

MINES AND CLAIMS

Brannigan Mine (Gold). The property comprises 3 claims with 4500 feet on the lode, situated in T. 13 N., R. 10 E., S. B. M., 14 miles southeast of Baker and 2 miles south of the Paymaster Mine, in the

Solo Mining District. Elevation 2200 feet. Owners, M. A. Sisley, Fred Hankins, Taft, California.

The vein which strikes N. 10° E., dips 70° west, cuts the quartzite, the bedding planes of which dip 20° southeast. The vein is from 12 inches to 2 feet in width. The vein filling is iron-stained quartz, showing considerable red and yellow ocher which is rich in free gold. Where the vein cuts the bedding planes of the quartzite, considerable mineralization occurs along the bedding planes. About twenty feet north of the portal of the tunnel, on the west side, one of the bedding planes shows 4 feet of iron-stained ore for a length of about twenty feet. Samples cut at intervals in this section of the vein assayed from $58 to $144 per ton over widths of 4 feet. Ten tons of ore milled at the Wanderer Mill is stated to have carried $125 per ton in gold.

Development consists of tunnel 125 feet in length, driven north on the vein.

Equipment consists of Ingersoll-Rand compressor type No. 14, driven by automobile engine; air drills and truck.

The owners are building a road to the mine and are planning to ship selected ore to the United States Smelting, Refining and Mining Company's smelter at Midvale, Utah.

Four men are employed.

Chesterfield and Old Gold Group of Claims. It comprises 3 claims situated in Secs. 16 and 17, T. 15 N., R. 11 E., S. B. M., 4½ miles east of Halloran Springs. Elevation 3500 feet. Owners, A. W. Brown, A. A. Brown and C. L. Brown, of Salina, Utah.

Three parallel veins occur in granite with an east and west strike, dip 30° N. Width 12 inches. Vein quartz copper-stained and mineralized with chalcopyrite.

Development consists of shaft 15 feet deep.

The east and west veins will intersect the Telegraph vein. On Old Gold Claim there is a narrow vein of iron-stained quartz which strikes N. 30° E. and dips 45° NW.

C. H. and P. A. (Sunset) Group. This group is situated one mile west of Yucca Grove and 3½ miles east of Halloran Springs. Owner, *Arrowhead Gold Mining Company,* Salt Lake City, Utah.

Two parallel veins occur in granite; strike N. 30° W., dip 70° W. These calcite-quartz veins have a width of 12 inches to 2 feet.

Development consists of shallow shafts and opencuts made at intervals along the outcrops.

Coin Stock Group of Claims. This group comprises 11 claims, situated in Secs. 18 and 17, T. 15 N., R. 11 E., S. B. M., 4 miles east of Halloran Springs. Owners, William Boddin and Alec Watkins, of Venice, California. Under lease and bond to Vivian and Robert Burns, of Salina, Utah.

A series of parallel calcite-quartz veins occur in granite, strike north to N. 30° E., dip vertical. The vein material is principally calcite, which is iron-stained, showing some free gold. The veins have a width of 4 feet.

Development consists of shafts from 10 to 50 feet deep on the different vein outcrops.

Contact Claim. It is situated one-half mile east of Yucca Grove station, on the Arrowhead highway. Owners, Vivian and Robert Burns, of Salina, Utah.

The vein occurs on contact of granite and limestone. Development consist of shaft 40 feet deep.

Diamond G Group of Claims. It comprises 4 claims located one-half mile west of Halloran Springs on north slope of Calico Hill. Owner, A. Miller, Westmoreland, California.

A series of roughly parallel pegmatite veins occur in gneissoid granite. The veins strike N. 30° W. dip vertical. The vein quartz is iron-stained; also shows copper stain from oxidation of chalcopyrite. Several shallow opencuts have been made along the outcrop of the pegmatite veins.

Friday and Saturday Group of Claims. This group comprises 8 claims, located 1½ miles south of Halloran Springs. Owner, C. W. Coyle, of Palo Alto, California.

A series of parallel outcrops of porphyry occur in granite. Strike NW. and SE.

Gold Bar Group of Claims. It comprises 3 claims situated in Sec. 9, T. 15 N., R. 11 E., S. B. M., one-quarter of a mile northwest of Yucca Grove station, on Arrowhead highway and 18 miles east of Baker, a station on the Tonopah and Tidewater Railroad. Elevation 4900 feet. Owners, Chas. A. Kellogg, D. W. McConnell, of Los Angeles.

A series of parallel calcite-quartz veins occur in granite. Strike north and south, dip 45° W. Widths vary from 2 to 4 feet. Vein quartz mineralized with hematite, pyrite and chalcopyrite. Also, east and west system of calcite-quartz veins. These veins are copper-stained and vary in width 12 inches to 2 feet. Reported to carry from $4 to $9 in gold.

Development consists of shallow prospect shafts.

Gold Bug Claim. It is situated 1½ miles south of Halloran Springs. Owner, John Burgess, of Hiawatha, Utah.

A quartz vein 4 to 6 feet wide occurs in gneissoid granite. The veins strike east and west, and dip 70° N. A diorite dike occurs on hanging wall of vein.

Development consists of shaft 10 feet deep. Samples taken from shaft reported to carry $6 to $10 in gold.

Gold Pin Group of Claims. This group comprises 26 claims located in Sec. 16, T. 15 N., R. 10 E., S. B. M., about 2 miles west of Halloran Springs. Elevation 3300 feet. Owner, *Arrowhead Gold Mining Company, Ltd.*; George W. Snyder, president; Guy M. Snyder, secretary; Robert Burns, superintendent, Salt Lake City, Utah.

A calcite-quartz vein 8 to 10 feet in width occurs in a shear zone in granite. The vein strikes N. 30° E. and dips 60° W. A shaft has been sunk on the vein to a depth of 80 feet. At a point 50 feet below the collar of shaft, there is a drift driven north 35 feet. Samples cut for a distance of 35 feet are said to have an average value of $3.40 in gold and 3.6 ounces in silver. Samples cut at intervals of 5 feet from

collar of shaft to bottom are said to have an average value of $16 per ton in gold.

Equipment consists of Ingersoll-Rand portable compressor, capacity 110-cu. ft. and air drills. Water was encountered at a depth of 80 feet.

These claims are all located on Sec. 16, a school section owned by the State of California.

Six men are employed.

Gold Streak Group of Claims. It comprises 2 claims, situated 2 miles west of Halloran springs and one mile north of the Arrowhead highway. Owner, A. A. Brown and Ralph Brown, Salina, Utah.

A calcite-quartz vein occurs in granite; strike N. 50° E., dip vertical. Width of vein is 4 to 6 feet.

Development consists of opencuts and shallow prospect shafts.

Hillside Group of Claims. It comprises 3 claims situated 4 miles northwest of Halloran Springs and 2 miles east of the Wanderer Mine. Owners, A. A. Aleck and F. L. McClure, Silver Lake, California.

A vein of quartz about 2 feet in width occurs in granite. Strike N. 30° E., dip 50° SE. The vein material is iron-stained, being mineralized with visible specks of gold, associated with pyrite and chalcopyrite.

Development consists of a number of shafts from 30 to 50 feet in depth sunk at intervals along the outcrop of the vein. It is reported that the early production of this property amounted to $10,000.

Imperial Group of Claims. It comprises 7 claims situated about one-half mile east of the Hillside Group and 4 miles northwest of Halloran Springs. Owner, G. H. Miller, Westmoreland, California.

Two parallel veins strike N. 30° E., dip 30° to 40° SW. Width 12 inches to 2 feet. Formation granite. The vein quartz is iron-stained and mineralized with pyrite and chalcopyrite.

Development consists of opencuts and trenches made along outcrop of veins.

Iron King Group of Claims. This group comprises 5 claims, situated 3 miles northwest of Halloran Springs. Owners, G. W. Miller and C. W. Coyle, Palo Alto, California.

Two systems of quartz veins occur in the granite, one strikes north and south, the other northeast and southwest. The veins dip 30° to 50° E. Width of veins varies from 12 inches to 2 feet. The vein quartz is mineralized with hematite, pyrite and chalcopyrite.

Development consists of a number of incline shafts from 10 to 50 feet in depth.

La Paloma Group of Claims. It comprises 6 claims located in the Solo Mining District and adjoins the Paymaster Group on the southeast, being 11 miles southeast of Baker, a station on the Tonopah and Tidewater Railroad. Elevation 2500 feet. Owner, Mrs. Katherine O. Sheehan, of Los Angeles.

The vein, which occurs in quartz, strikes N. 50° W., dips 65° NE. Width 12 inches to 2 feet. Vein quartz is iron-stained and shows free gold.

Development consists of tunnel 10 feet in length and shallow prospect holes. Idle.

Last Chance Group of Claims. It comprises 5 claims situated on the northwest slope of Calico Hill, one mile west of Halloran Springs. Owner, C. W. Coyle, of Halloran Springs.

A series of roughly parallel pegmatite vein-dikes occur in gneissoid granite. The general strike of these veins is north and south, with a dip of 40° to the west. The vein outcrops are stained with copper, being oxidization from chalcopyrite.

Development consists of surface cuts.

Lost Lead Group of Claims. This group of claims consists of 15 claims situated in the center of the Halloran Springs Mining District, in Secs. 8, 9, 16 and 17, T. 15 N., R. 11 E., S. B. M., 4 miles east of Halloran Springs. Owners, M. W. Woolley, W. H. Eardley and Robert Burns, Salt Lake City, Utah.

A series of parallel calcite-quartz veins occur in granite. There are two systems of veins, one of which strikes north and south, the other system strikes N. 30° to 50° E. The major part of the development work on this group of claims is confined to Lost Lead No. 3 and Lost Lead No. 11 and No. 12 claims. On Lost Lead No. 3 claim, a calcite-quartz vein strikes north and south, dips 40° W. It has a granite hanging and footwall. The vein has a width of 2 to 3½ feet.

Development consists of incline shaft 42 feet deep. It is stated that a sample cut across 3½ feet of vein quartz at a depth of 40 feet assayed $24 in gold. A sample taken from a 6-inch streak on the footwall of vein is said to assay $50 in gold per ton.

On the north wall of an epidote dike which strikes N. 50° E. and dips 30° SE., an incline shaft is being sunk on a 12-inch vein. The footwall of this vein is granite, with the dike being the hanging wall. This shaft is located near the side line of No. 12 claim.

On Lost Lead No. 12 claim, a shaft has been sunk to a depth of 10 feet on a calcite-quartz vein in granite. The vein is 4 to 6 feet in width, strikes north and south, with a dip of 70° to the west. Sample cut across 4 feet of vein material is reported to assay $7 per ton in gold.

Six men are employed.

Mammoth Group of Mines. It comprises 2 claims located 4 miles west of Halloran Springs. Owner, C. W. Coyle, Palo Alto, California.

A wide outcrop of quartz occurs in granite; strike north and south. The vein quartz is mineralized with galena, pyrite and chalcopyrite.

Development consists of surface cuts.

Mammoth Group of Claims. It comprises 6 claims, adjoining the Coin Stock Group on the west. Owner, Vivian and Robert Burns, Salina, Utah.

Two parallel calcite-quartz veins occur in the granite. The most easterly vein occurs along an aplite dike that strikes northeast and southwest. The veins strike N. 30° E., dip 50° W. Widths vary from 4 to 6 feet.

Development consists of a shaft 35 feet in depth. Samples cut at intervals down this shaft are reported to assay from $6 to $12 per ton in gold.

Mizpah Group of Claims. It comprises 5 claims situated 4 miles northwest of Halloran Springs and adjoins the Imperial Group of claims on the east. Owner, Vivian Burns and Robert Burns, of Salina, Utah.

An iron-stained vein of quartz strikes N. 20° E. and dips 45° E. It occurs in granite. Width of vein is 2 feet. A series of parallel, porphyry dikes which strike east, cut through the vein.

Development consists of an incline shaft 60 feet in depth.

Oro Fino Group of Claims. It comprises 2 claims, adjoining the Paloma group on the northeast, situated in the Solo Mining District, 11 miles southeast of Baker. Owner, Jones Lindy, Big Pine, Wyoming.

The formation is mica schist, granite, overlain with quartzite and limestone. Vein strikes N. 30° E., dips 45 W. Width is 12 inches to 3 feet.

Development consists of two shallow shafts. Idle.

Paymaster Mine, Solo Mining District, San Bernardino County.

Paymaster Mine (Whitney). It comprises 8 claims, known as Paymaster Group of Claims, situated in the Solo Mining District, in T. 13 N., R. 10 E., S. B. M., 10 miles southeast of Baker, a station on the Tonopah and Tidewater Railroad. Elevation 1800 to 2400 feet. Owners, William Foster and Gus Foster, Baker, California. Under option to John Herrod, M. A. Sisley and Fred Hankins, of Taft, California.

It was discovered in 1900 and operated from 1910 to 1914 when closed on account of litigation. There was a 10-stamp mill on the property which was operated with water secured from Indian Springs. It is reported that $12 per ton in gold was recovered by amalgamation, with a loss of $4.50 per ton in tailings. It is reported that during this

period of operation some high grade bunches of ore were encountered 150 feet above tunnel level and shipments of ore to the smelter carried \$100 per ton in gold. The reported production of the mine varies from \$50,000 to \$100,000.

Three parallel veins known as Paymaster, Sidewinder and Lost Horse, occur in granite which is overlain by quartzite and limestone on the south end of the claims. These veins vary in width from 2 to 6 feet. Strike N. 30° to 40° E., dip 50° N. The vein quartz is mineralized with free gold, iron pyrite, magnetite, chalcopyrite and marcasite. The value of the ore ranges from \$2 to \$20 per ton. Average value is reported to be \$10 per ton in gold. At an elevation of 2080 feet, the lower crosscut tunnel is driven S. 40° E., 748 feet to the Paymaster

Portal of lower tunnel, Paymaster Mine, Solo Mining District, San Bernardino County.

vein, with drift south on the vein for a distance of 240 feet and north 465 feet. The vein in north drift has an average width of 6 feet and is reported to have an average value of \$8 per ton in gold. In the south drift the quartz varies in width from 12 inches to 2 feet. About 75 feet south of crosscut, a winze has been sunk to a depth of 15 feet. At an elevation of 2350 feet there is an air shaft which was sunk in rhyolite porphyry dike about 75 feet wide and has the same general course as the Paymaster vein. The shaft was sunk to a depth of 170 feet on an incline of 50°. A shoot of ore was encountered at this depth. A raise from tunnel level connects with the 170-foot level from this shaft. About 150 feet north of the air shaft, there is a shaft sunk on the Paymaster vein to a depth of 152 feet.

The Lost Horse and Sidewinder veins have been prospected along their outcrops by a number of shallow shafts from 10 to 25 feet in depth.

The vein quartz from these shafts pans free gold and is said to have an average value of $8 per ton.

The present company has installed a 2-inch pipe line for a distance of 3 miles. There remains about 2 miles of pipe line to install to the well on the east shore of Soda Lake.

Three men are employed.

Prince Group of Claims. This group comprises 21 claims situated in the Halloran Springs District, adjoining the Coin Stock and Lost Lead claims on the east, in Secs. 8 and 9, T. 15 N., R. 11 E., S. B. M., about 4 miles east of Halloran Springs. Owner, *Arrowhead Gold Mining Company,* Salt Lake City, Utah.

The northeastern portion of these claims is covered by a basalt flow and very little development has been done on this group of claims. Where the granite is exposed, there are a number of calcite-quartz veins which strike N. 30° to 50° E.

Revenue Group of Mines. It comprises 4 claims situated 4 miles southeast of Halloran Springs. Owners, A. A. Brown, Ralph Brown and Bruce McDonald, Salina, Utah.

Two parallel veins occur in granite, strike NW. and SE., dip 40° SW. Width 2 to 3 feet. Vein quartz is mineralized with pyrite, marcasite and chalcopyrite. Reported selected sample of ore from mine dump assayed $56 per ton in gold.

Development consists of shaft 30 feet deep sunk on the vein.

Silver King Group of Claims. It comprises 40 claims situated 2 miles south of Halloran Springs. Owners, Lorin Hall and associates, of Los Angeles.

The vein system on this group of claims consists of a series of parallel quartz-porphyry veins in granite. These veins strike northwest and southeast. A massive outcrop of quartz strikes east and dips 45° south. Width 4 to 8 feet. Vein quartz is mineralized with galena, pyrite and chalcopyrite and reported to assay $4 to $10 per ton.

Development consists of shallow prospect shafts and opencuts.

Sunrise Group of Claims. It comprises 6 claims situated in the Solo Mining District, 11 miles southeast of Baker, a station on the Tonopah and Tidewater Railroad. Elevation 2000 feet. Owner, Peter Flury, of Baker, California.

A series of parallel veins occur in granite, strike NE. and SW., dip 70° SE. Widths vary from 12 inches to 2 feet.

Development consists of a series of shafts from 10 to 25 feet deep. Idle.

Sunset Group of Claims. This group comprises 5 claims situated in the Solo Mining District, 14 miles southeast of Baker, a station on the Tonopah and Tidewater Railroad. Elevation 2500 feet. Owner, Ross Fitch, of Los Angeles.

A series of parallel veins occur in quartzite, strike N. 40° E. to N. 60° E., with dips varying from 50° to 60° west. The veins vary in width from 12 inches to 8 feet.

On the west end of the claims on ridge north of Brannigan wash, there is a massive outcrop of quartz about 8 feet in width. This vein strikes N. 40° E. and dips 50° west. It has been developed by an incline

shaft sunk on the footwall side of the vein to a depth of 80 feet. At this point the vein assumes a dip of 30° west and has been followed on incline of 30° for a distance of about 30 feet. Near collar of shaft on the hanging-wall side of vein, the vein quartz shows specks of free gold. The outcrop can be followed for a distance of 3000 feet. About 350 feet southwest, at a lower elevation, there is a shaft sunk on a parallel vein to a depth of 60 feet. The vein has a width of 12 inches.

Telegraph Group of Mines. This group comprises South Telegraph, Telegraph, and Telegraph Extension claims, totaling 60 acres, situated in Secs. 16 and 17, T. 15 N., R. 11 E., S. B. M., 4½ miles east of Halloran Springs. Elevation 3500 to 4000 feet. Owners, A. A. Brown, Ralph Brown, Arthur Nelson and Beau McDonald, Salina, Utah. Under option to George Keating, of Los Angeles.

Calcite-quartz vein occurs in granite, with a strike of N. 30° E. and dip of 30° NW. Width of vein varies from 4 to 8 feet. The vein occurs along aplite dike that has the same general strike and dip. This dike forms the footwall of the vein with a granite hanging-wall.

On the above-mentioned claims are a number of small, rounded hills or small buttes where the vein outcrop is prominently exposed but between these buttes or hills it is covered by alluvium. On Telegraph Extension Claim, the first high grade ore was found in the district by Ralph and A. A. Brown on November 19, 1930.

A shaft is sunk on the vein to a depth of 10 feet, exposing 4 to 6 feet of calcite-quartz vein material. Samples cut from the vein in this shaft and from opencuts and trenches along the outcrop for a distance of 150 feet, are reported to carry from $4.40 to $22 per ton in gold and 3 to 11 ounces in silver.

On Telegraph Claim, the vein outcrop is exposed for a distance of 500 feet. Samples taken from trenches and shallow opencuts along the outcrop of vein are said to have assayed from $1 to $112 per ton in gold, with 2 to 6 ounces in silver.

South Telegraph Claim. On this claim the vein outcrop is exposed for a distance of 450 feet. Samples cut from trenches and opencuts made at intervals along the outcrop are said to carry from $4 to $21.60 per ton in gold, with from one to 10 ounces in silver.

A 2-compartment incline shaft is being sunk on the South Telegraph Claim near the south end of the exposed outcrop. The present depth of the shaft is 30 feet, sunk on an incline of 30°. In this shaft on the footwall of the vein there is exposed 2 inches of high grade ore. Sample cut from this high grade streak assayed $674 per ton in gold with 25.5 ounces in silver per ton.

Equipment consists of blacksmith shop and tent buildings. Four men are employed.

Utah Group of Claims. This group comprises 12 claims adjoining the Gold Pin Group on the east. It is situated in Sec. 15, T. 15 N., R. 11 E., S. B. M., 1½ miles west of Halloran Springs and west of Halloran wash. Elevation 2500 feet. Owner, *Arrowhead Gold Mining Company*; George W. Snyder, president; Guy M. Snyder, secretary; Robert Burns, manager. Offices, Salt Lake City, Utah.

The mineralization on these claims is confined to a sheer zone in the granite which is 500 feet in width and 2000 feet in length.

A series of parallel, calcite-quartz veins, heavily iron-stained cut the granite. These veins vary from narrow stringers to 2 feet in width and strike N. 50° E. It is reported a large number of samples were taken at intervals from trenches in this area. The average value was $2.20 per ton in gold, with 2 ounces in silver.

The company proposes to work this property in conjunction with the Gold Pin Group of Claims.

Yucca Palm Group of Claims. This group comprises 35 claims, 7 claims in length by 5 claims in width, with 10,500 feet on the lode. It is situated in Secs. 17 and 20, T. 15 N., R. 11 E., S. B. M., 3 miles east of Halloran Springs. The claims are located on slope of ridge southwest of basalt lava flow, the most northerly claims being covered with basalt.

Three parallel calcite-quartz veins occur in granite below the basalt flow. These veins strike N. 30 to 50° E. and dip 70° SE. Widths vary from 3 to 6 feet. A series of parallel aplite dikes, which strike northeast and southwest occur on this group of claims. The vein quartz is heavily stained with hematite and carries free gold with pyrite.

A shaft is sunk on vein to a depth of 30 feet on the Yucca Grove Claim No. 5. Samples cut from the vein in this shaft are said to assay from $3 to $30 per ton in gold. The vein outcrops on other claims have been prospected with shallow opencuts and prospect shafts.

Two men are employed.

IRON

Large deposits of iron ore occur in the desert regions of San Bernardino County. It is estimated that there are 200,000,000 tons of high grade ore available and double that amount of probable ore in Riverside and San Bernardino counties. The iron ore deposits of San Bernardino County eventually will become of importance, both on account of the exhaustion of high grade ores in the eastern section of the country and because of the necessity for supplying the growing demands of the Pacific Coast.

Geology.

The principal iron deposits of Riverside and San Bernardino counties are the contact replacement type that form at or near the contact of an intrusive igneous mass with sedimentary strata, usually limestone.

For detail description of the different deposits see U. S. G. S. Bulletin No. 285, p. 198; U. S. G. S. Bulletin No. 430, pp. 228–239; Bulletin of A. I. M. E., September, 1915; State Mineralogist's Report IX, p. 235; Report XV, pp. 817–821; Bulletin No. 38, p. 299.

Deposits.

Cave Canyon Iron Deposit. It is situated in Secs. 12 and 13, T. 11 N., R. 7 E., S. B. M. Holdings consists of 10 claims known as the Cave Canyon Group (all patented), about one-quarter of a mile north of Baxter, a station on the Union Pacific Railroad. Owner, E. H. Harriman Estate, New York City.

The iron ore occurs on the contact of monzonite and a coarsely crystalline marble on the south, dipping southward at about 30°. The ore occurs in two belts. The western belt is 2000 feet long and the eastern 1700 feet in length. The width of the outcrop reaches a maximum of 450 feet. The average width of the western belt is 300 feet and the eastern belt has a width of 100 feet. The ore is mainly red hematite and limonite. Commercial analysis shows 60% iron, with low phosphorus.

Development consists of four tunnels. Estimated tonnage is 10,000,000 tons.

Bibl: State Mineralogist's Report XV, p. 818; Bull. 38, p. 299.

Iron Age Iron Deposit. It comprises 3 patented claims, situated in Sec. 29, T. 1 S., R. 13 E., S. B. M., 6 miles east of Dale, and about 45 miles by road south of Amboy, a station on the Santa Fe Railroad. Owner, A. R. Rhea, Los Angeles.

The iron ores are largely hematite, altered from magnetite, in the form of veins cutting intrusive granite and granite porphyry. The principal iron-ore veins occur over an area about one-half mile square, the larger ones forming the summit of a large hill. The ores are very pure and high grade but the veins are not of sufficient extent to warrant the possibility of developing a large tonnage.

Bibl: State Mineralogist's Report XV, pp. 818–819; Bull 38, p. 299; U. S. G. S. Bull. 340, pp. 228–239.

Iron Hat Group (formerly called the *Ironclad Group*), of 7 claims, is in the Marble Mountains, 14 miles east of Amboy. Elevation about 4000 feet. Owner, T. Schofield, Amboy, California.

The rocks exposed on this property consist of dolomitic limestone, felsite, quartz porphyry and diorite. The limestone has been pushed up and intruded by the igneous rocks. It now outcrops in the shape of a crescent. The strike varies from northwest in the canyon to northeast on the south slope of the mountain. On the north end of the property, a quartz porphyry is in contact with the dolomitic limestone. In fact, practically all of the exposed contacts consist of quartz porphyry and limestone but where tunnels have been driven there is a varying thickness of diorite between the two.

The deposits are on the contacts, dip from 50° to 85° in an easterly direction. In the canyon an iron 'vein' outcrops. It is from 8 to 10 feet wide, strike NW., dip 80° NE. At the top of the mountain to the north this 'vein' merges into a very prominent iron outcrop, having a total width of 40 to 50 feet, with a narrow diorite dike in its center. In a canyon northeast of this ridge, this outcrop disappears but shows again very prominently on the next ridge. It is from this second ridge that some 2000 tons of ore were shipped to the Llewellyn Iron Works in Los Angeles. This ore is reported to have averaged 65% iron. The ore is a black hematite, with some specular iron and magnetite.

Development work consists of two tunnels, one 40 feet long and the other 100 feet. The 100-foot tunnel is a crosscut, which passes through the quartz porphyry and into the ore at a distance of 60 feet from the portal. These tunnels and various opencuts constitute the development work.

Idle except for assessment work.

Iron Mountain Deposit. This deposit is in the Lava Bed Mining District, in Secs. 27 and 28, T. 6 N., R. 4 E., S. B. M., about 18 miles southeast of Newberry, a station on the Santa Fe Railroad. Holdings comprise 7 claims, totaling 140 acres. Owners, Mrs. Phoebe Owens, San Francisco, and E. S. Lake, Los Angeles. Elevation 3000 to 3880 feet.

Two massive veins of hematite and magnetite iron ore occur on a ridge known as Iron Mountain, which is the southeasterly prolongation of the Ord Range of mountains. The veins of iron ore occur in granitic rocks; they strike N. 20° E., dip 30° NW. The veins are about 150 feet apart and vary in width from 30 to 400 feet. The ore occurs on contact of dolomitic limestone and granite on the Tip Top Claim. On the Bessemer Claim, the strike of the large deposit of iron ore is north and south. The iron ore deposits can be traced along their strike for a distance of 320 feet, with an average width of 80 feet, increasing in places to 400 feet. The deposit is reported to contain 10,000,000 tons of commercial ore.

Analysis of ores is as follows: Iron, 65%; phosphorus, .045%; silica, 3.05%; sulphur, .06%.

Bibl: State Mineralogist's Reports IX, p. 235; XV, p. 819. S. M. B. Bull. 38, pp. 299–300.

Iron Mountain Group is in Secs. 11, 12, 13 and 14, T. 15 N., R. 6 E., S. B. M., 10 miles west of Silver Lake, a station on the Tonopah and Tidewater Railroad. Holdings comprise 6 patented claims. Owner, *Colorado Fuel and Iron Company,* Denver, Colorado.

There is 12,000,000 tons of commercial ore in this deposit.

Bibl: State Mineralogist's Report XV, p. 820.

Kingston Mountains Iron Deposit. A large deposit of iron ore occurs in the Kingston Mountains, in T. 25 S., R. 11 E., S. B. M., 25 miles southeast of Sperry, a station on the Tonopah and Tidewater Railroad. Owner, *Pacific Coast Steel Company,* San Francisco. Holdings comprise 6 patented claims.

The ore is hematite and magnetite which occurs near the contact of intrusive mozonite and limestone. During recent years the deposit was thoroughly prospected with diamond drills by the above-mentioned company, and it is estimated that the deposit contains 12,000,000 tons of commercial ore. Idle.

Bibl: Bull. 38.

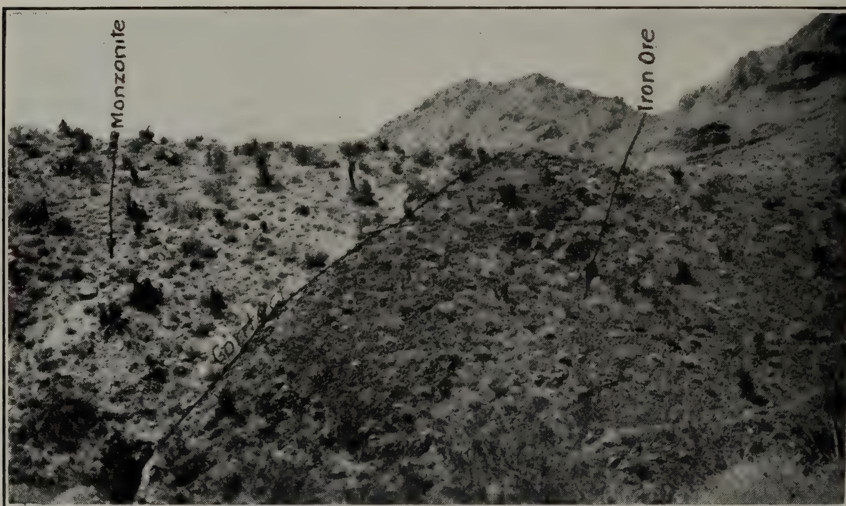
Ship Mountains Iron Mine, consisting of 7 claims, is in the Ship Mountains, $2\frac{1}{2}$ miles south of Siam, a station on the main line of The Atchison, Topeka and Santa Fe Railroad. Elevation about 3500 feet. Owner, Earl W. Paul, Upland, California.

Although this property has been developed by a 500-foot shaft, observations could only be made on the surface, as a recent fire had destroyed the surface plant, burning the timbers in the shaft and causing it to cave. This was very unsatisfactory as the entire surface is covered with vesicular, basaltic boulders.

The mineralized zone, strike N.-S., dip 45° E., has a diabase hanging wall and dolomitic limestone footwall. It is traceable for about

one mile on this property. The ore is red hematite and in places it shows oxides of copper and copper sulphate stains. This zone has a width up to 600 feet and appears to consist of a series of veins in the diabase, with the limestone as the footwall of the zone and the principal vein is at the contact.

It is reported that 30 cars have been shipped to the Southern California Iron and Steel Company and to the Llewellyn Iron Works. It is said that it averaged 60% iron, with low sulphur and silica and practically no phosphorus.



Vulcan iron deposit. Outcrop 385 feet wide by 80 feet high.

Development is reported to consist of a 500-foot inclined shaft with the following lateral developments:

Level	*Drift North*	*Drift South*
100-foot	Approximately 50 feet	Approximately 50 feet
150-foot	Approximately 75 feet	Approximately 75 feet
200-foot	Approximately 75 feet	Approximately 75 feet
250-foot	Approximately 70 feet	Approximately 65 feet
400-foot	Approximately 65 feet	Approximately 70 feet
500-foot	Approximately 25 feet	

There were 2 stopes on the 100-foot level. The ore in one of these is reported to have a width of 30 feet. The ore was encountered in all of these levels except the 500 foot.

It is reported that the claims are now being patented.

Vulcan Iron Deposit. It is situated in the Providence range of mountains, 9 miles southeast of Kelso, a station on the Union Pacific Railroad. Elevation 3700 feet. Holdings comprise 5 patented claims containing 100 acres, in Sec. 25, T. 10 N., R. 13 E., S. B. M. Owner, C. Colcock Jones, Los Angeles.

The ore deposits are typical contact iron replacements of dolomitic limestone at or near an intrusive mass of monzonite. On Vulcan No. 2

Claim, there is exposed a solid mass of iron ore 800 feet in length and 350 feet in width, which rises to a height of 260 feet at the east end and 80 feet at the west end of the deposit. The area of this outcrop of iron ore is 4 acres. It is estimated that this deposit contains from 4,000,000 to 8,000,000 tons of commercial ore. A number of smaller outcrops occur along the contact of the limestone and monzonite at intervals for a distance of 4000 feet. The ore is a soft hematite and from analysis contains: Iron, 64.83%; phosphorus, 0.044%; silica, 3.04%; sulphur, .06%.

Development consists of one tunnel, shafts and opencuts. Idle.

Bibl: State Mineralogist's Report XV, pp. 820–821; Bull. A. I. M. E., September, 1915, p. 1889; E. and M. Journal, April 17, 1909.

MANGANESE

Deposits of manganese ore occur in the desert regions of San Bernardino County, in the Lavic Mountains, Owl Mountains, Whipple Mountains and along the Colorado River near Parker. The only deposit of commercial importance, so far developed, is the Owl Hole Manganese Mine, in the Owl Mountains, 36 miles west of Riggs, a station on the Tonopah and Tidewater Railroad. This deposit was extensively worked from 1915 to the latter part of 1918, and produced a large tonnage of high grade ore; of the other deposits mentioned, the silica content is too high to make them of commercial importance.

Deposits.

Black Stone Manganese Deposit. It is 3 miles southeast of Afton, a station on the Salt Lake Railroad, on ridge east of the Mojave River. Elevation 2600 feet. Owner, J. H. Massen, Yermo, California.

A series of lenses of manganese occur on contact of granite and limestone, for a distance of about 1000 feet. The strike of the contact is north and south, with a dip of 70° to the east. The largest lens noted was about 60 feet in length and 8 to 10 feet wide. The fracture can be traced for a mile and at intervals shows from 8 inches to 4 feet of ore. Manganese occurs in the form of psilomelane, with a small amount of pyrolusite. Idle.

Bibl: State Mineralogist's Report XVII, p. 354.

Emma Group of Manganese Claims. The deposit is located 36 miles west of Riggs, a station on the Tonopah and Tidewater Railroad, about one mile north of the Owls Hole Mine. Owner, Ruben Stinton, Silver Lake, California.

At an elevation of 2800 feet, on ridge north of Owls Hole Mine, a vein of manganese occurs on contact of granite and limestone. The outcrop can be traced along the contact for several hundred feet. Manganese occurs as pyrolusite and shows a low silica content. Developments consist of a series of short tunnels. Idle.

Bibl: State Mineralogist's Report XVII, p. 354; Bull. 76, p. 62.

Lavic Mountain Deposits. These deposits are situated 5 miles northwest of Ludlow in the Lavic Mountains. Owners, Al. Seymour, I. D. Garinger and L. N. Root, Daggett, California.

Manganese oxides occur along a series of parallel fractures in a rhyolite breccia. The outcrops can be traced for a distance of one mile. The veins strike N. 60° W., with dip of 60° SW. The veins have widths of 12 inches to 3 feet. Ore is psilomelane. Developments consist of a series of open cuts on different veins. In 1917, 100 tons of ore were shipped from the property. Ore carries high silica content. Idle.

Bibl: State Mineralogist's Report XVII, pp. 354–355; Bull. 76, p. 62.

Owls Hole Manganese Mine. It is situated 36 miles west of Riggs, a station on the Tonopah and Tidewater Railroad, northwest of Owl Hole Spring, Owl Mountains, and southwest of Death Valley narrows. Elevation 2400 feet. Formerly under option to C. E. Starr, Los Angeles; 40 claims of this group are owned by E. W. and E. E. Williams and two claims by G. W. Rose, Silver Lake, California.

The manganese oxides occur along a series of fault fractures which strike NW. and SE. in granite and also on contact between the granite and limestone, the latter at one time covering the whole area of the granite, but has since been mostly eroded. At different points the granite is overlain by granitic conglomerate.

Two shafts have been sunk to a depth of 60 feet along these fractures, which are more or less parallel. The ore developed in these workings shows a width of 4 to 6 feet. There is also an open cut 150 feet in length on a parallel vein about 50 feet west of north shaft, showing 3 feet of ore in south face of cut. North of shaft in gulch there is an open cut where the manganese oxides occur on contact of limestone and a granitic conglomerate. The croppings at this point are 50 feet wide, and the ore is intermixed with the granitic conglomerate. At the edge of this cut a shaft is sunk 50 feet in ore. About 1½ miles north of these workings there is a large body of manganiferous iron croppings 200 to 300 feet long and about 50 to 75 feet wide. Developed by a series of open cuts. Manganese oxides are psilomelane, pyrolusite and manganite. Calcite occurs in the fracture with the manganese oxides. Ore shipped from the property is stated to have carried 45% to 70% MnO_2. Ore was hauled by tractor and trucks to Riggs Station. Idle. Reported that production is to be started at this property in the near future.

Bibl: State Mineralogist's Report XVII, p. 355; Bull. 76, pp. 62–64.

Red Cross and Hidden Treasure Groups of Manganese Claims. These claims are located 11 miles north of Drennan, a station on Parker Branch of the Santa Fe Railroad, in the Whipple Mountains. Elevation 2300 feet. Owners, Fred W. Hall and Mrs. Maude Washbesh, Parker, Arizona.

Manganese ore occurs as lenticular and irregular masses in the sandstone, limestone and volcanic breccia. Some of the orebodies are connected with northwesterly fissures along bedding planes. There are many outcrops of ore on the claims, but only a few have been exploited. One deposit enclosed in volcanic breccia is 25 feet long and 4 feet wide. At two other places ore occurs in fissures in the limestone. Bodies are 8 feet wide and 25 feet long. Manganese ore consists of massive psilo-

melane with a small amount of pyrolusite present. The ore is high grade. Shipments of ore are stated to have yielded 45% manganese, 4% silica, 2% iron, and 0.04% of phosphorus. Idle.

Bibl: State Mineralogist's Report XVII, pp. 355–356.

MOLYBDENUM

The two principal molybdenum minerals are the sulphide, molybdenite, and wulfenite, lead molybdate the former furnishing practically the entire commercial output. Molybdenite is found in or associated with acidic igneous rocks, such as granite and pegmatite.

Deposits of disseminated molybdenite are known in several localities in San Bernardino County. In the New York Mountains it occurs in small masses, associated with copper ores. Small kidney-like deposits of molybdenite also occur in a granitic gneiss on the ridge west of the south fork of Lyttle Creek, 2 miles west of Glen Ranch. The occurrence of molybdenum is also reported near Bonita Falls, on the south fork of Lyttle Creek. So far, no commercial deposits have been developed.

QUICKSILVER

Desert Mercury Group of 9 claims is in the Old Woman Mountains, 12½ miles southeast of Danby, a station on The Atchison, Topeka and Santa Fe Railroad. Owners, S. M. Mingus, Glendale, California; A. F. de Steiger, Danby, California A. F. Wagner, Chula Vista, California; and A. E. Barron, San Diego, California.

A series of roughly parallel quartz-porphyry dikes here occur in granitic gneiss. The strike is N. 80° E., dip 60° E. Mineralization has taken place along the contact in the quartz porphyry and, in places, has penetrated the joints of the gneiss for a few feet from the dike. These dikes are traceable for about 2000 feet or more, across the property. The only metallic mineral observed was cinnabar. The mineralized zones sometimes reach a thickness of 12 to 15 feet, probably averaging 4 to 5 feet. While samples have shown as high as 3% to 8% mercury, no idea as to the average content of the ore could be obtained.

Development work consists of a series of open trenches on the various contacts.

Idle except for assessment work.

Idria Quicksilver Group, consisting of 8 claims, is in Sec. 24, T. 9. N., R. 18 E., S. B. M., in the Sacramento range of mountains, about 5 miles south of Goffs, a station on the Santa Fe Railroad. Elevation about 2500 feet. Owners, Frank M. Chausse and Thomas H. O'Mill of Goffs, California, and Mrs. Marie B. Gage of Los Angeles.

Numerous parallel veins traverse the floor of the canyon in a hornblende granitic-gneiss. Strike N. 70° E, dip varies from 30° to 35° NW. The ore occurs along the main fractures and joints in the brecciated wall rock. The wall rock has been greatly altered along these lines, principally by silicification, in places showing as much as four feet of solid chalcedony, through which is disseminated cinnabar in minute particles. The veins vary in width from a few inches to eight feet. Values up to 4% mercury are reported, but sufficient work has not yet been done to warrant a statement as to average values.

Development work consists of open cuts and two shafts each 25 feet deep. Idle at present but the immediate sinking of a shaft is contemplated.

SILVER-LEAD AND ZINC

Alta Mine, consisting of 11 claims is situated on the northwest slope of the Shadow Mountains, 1¼ miles east of Riggs, a station on the Tonopah and Tidewater Railroad. Elevation 1800 feet. Owner, Mrs. Frank Riggs, 1801 Oxley street, South Pasadena, California.

The ore, which consists of native silver, galena and chlorobromides of silver, occurs in irregular lenses, along a series of north-south fault fractures and also at the intersections of these fractures, with east and west fissures, in the limestone. The north-south fissures dip 65° to 70° west and are filled with a heavily iron and manganese stained, porphyritic material. The high-grade ore, as a rule, is associated with barite.

Considerable development was done and a production of $200,000 was reported. Idle.

Bibl: State Mineralogist's Report XVII, p. 359.

Allie and Beatrice is an old property in the Ivanpah District, 20 miles northwest of South Ivanpah. Has long been idle.

Bibl: State Mineralogist's Report XV, p. 826.

Anaco Mine (formerly the *Red Rover*), comprising 12 claims, is in the Silver Mountain District, approximately 6 miles east of Silver Mountain, 5 miles north of Adelanto and 1 mile west of the Randsburg-San Bernardino highway. Elevation about 3000 feet. Owner, Anaco Mines Company; F. A. Rogers, president, San Gabriel, California; George W. Clark, secretary, Box 91, Adelanto, California.

Here a thick bed of dark, crystalline limestone has been intruded by a series of felsitic dikes, evidently offshoots from the granitic rock which marks the eastern boundary of the limestone. Strike of the limestone is N. 25° W., dip 75° to 85° to the west. The dikes seem to dip to the east. The ore occurs along the contacts of the dikes with the limestone and as a replacement along the bedding planes. Sufficient exploration work has not yet been done to determine the extent of the replacement. The most abundant metallic mineral appears to be sphalerite, with subordinate galena and silver minerals. No idea of average values could be obtained.

Developments consist of 100-foot vertical shaft (inaccessible) with a reported crosscut at the bottom, 15 feet west and a drift south. On the 25-foot level, present operators have drifted south 40 feet. This drift is connected by a raise to the surface, at a point 20 feet south of the shaft. Small, irregular lenses of ore occur throughout the length of this drift. It is reported that there is 4 feet of good ore in the bottom of the 100-foot shaft. A 70-foot vertical shaft was sunk 300 feet south of these workings. This is also inaccessible. Between the two shafts is an open cut about 50 feet long. About 1200 feet north of these workings, the limestone is split by an intrusive mass which has a width of approximately 200 feet. Here, on the western portion of the divided limestone, an old shaft was sunk to a reported depth of 136 feet but no further information regarding this work is available.

Four men employed. At the time of visit they were excavating for a hoist which was to be placed at the 100-foot shaft.

Avawatz Crown Mine is in the Silver Lake District, 8 miles east of Riggs, a station on the Tonopah and Tidewater Railroad. Owner, *Avawatz Consolidated Mines Company;* Alvin B. Carpenter, president; M. L. Neely, secretary. Offices formerly in Citizens National Bank Building in Los Angeles.

On this property a highly brecciated quartzite, 210 feet wide and exposed for a length of several thousand feet, is mineralized across its full width. The richest portion is that next to the hanging wall, sample of which gave an assay result of 150 ounces silver, 20% lead, with 5½% copper and 6% zinc. Samples taken across the entire width showed an average value of 4 ounces silver and 8½% lead. This ore is in the form of a silver-bearing galena.

Development consists of 325-foot shaft, with 210-foot crosscut on the 300-foot level. Idle except for assessment work.

Bibl: State Mineralogist's Report XVII, pp. 359–360.

Bank Roll and Green Gold Groups, consisting of 6 claims, are located in the Clark Mountain District, in T. 17 N., R. 13 E., S. B. M., on the west slope of Clark Mountain, 7 miles northeast of Valley Wells and 23 miles north of Cima, a station on the Union Pacific Railroad. Elevation 6000 feet. Owner, Louis F. Keiper, Cima, California.

Narrow fissures, 8 inches to 2 inches wide, in quartz monzonite, near its contact with limestones, are filled with quartz. The valuable minerals in the quartz gangue are galena, sphalerite and chalcopyrite, which carry values in gold and silver. Strike of the veins is north-south. The average value of the ore is reported to be 20 ounces of silver and 25% lead.

Development consists of a number of tunnels and open cuts on the various claims. Idle.

Bibl: State Mineralogist's Report XX, pp. 92–93.

Belcher Extension Mining Company, formerly operated in the Randsburg District. Their property was located southwest of the California Rand Silver Company's mine. A shaft was sunk to a depth of 432 feet and about 300 feet of drifting and crosscutting was done on the 230–330, and 430-foot levels. No commercial orebodies were developed. Idle.

Bibl: California State Mining Bureau Bull. 95, pp. 128–129.

Bell Gilroy Mine, comprising 3 claims, is in the Trojan District, on the eastern slope of the Providence Mountains, 22 miles northwest of Fenner, a station on The Atchison, Topeka and Santa Fe Railroad. Elevation, 4350 feet. Owner, A. A. Irish, 514 Grosse Building, Los Angeles.

The ore consists of argentiferous galena deposited in a silicified limestone breccia, near a contact with intrusive monzonite. The main orebodies occur at intersections of north and south fissures with east and west fissures. Developed by a number of short tunnels. Idle.

Bibl: State Mineralogist's Report XVII, p. 360.

Ben Hur Mine, consisting of one patented claim, on the line between San Bernardino and Kern Counties, is in the Randsburg District. It is about one-half mile southwest of the California Rand Silver Mine.

The Ben Hur Divide Mining Company sunk a $1\frac{1}{2}$-compartment shaft to a depth of 400 feet on this property. They also did approximately 2000 feet of horizontal work on the 200-, 300- and 400-foot levels. This work prospected three veins which occur on the property, without disclosing an orebody of commercial value. Idle.

Bibl: California State Mining Bureau Bull. 95, p. 129.

Bevis Divide Mining Company sunk a 150-foot shaft on a small piece of ground leased from the Pittsburg and Mt. Shasta Mining Company in the Randsburg District. No vein was discovered. Idle.

Bibl: California State Mining Bureau Bull. 95, p. 129.

Big Four Mine is in the Randsburg District. The *Rand Consolidated Silver Mining Company, Inc.,* sunk a shaft on this property to a depth of 130 feet. This shaft is located about 3300 feet northeast of the No. 2 shaft of the California Rand Silver Mine. No ore was encountered in these workings. Idle.

Bibl: California State Mining Bureau Bull. 95, p. 129.

Big Six. A small property lying east of the railroad in the silver belt of the Randsberg District. A shaft was sunk to a depth of approximately 300 feet without disclosing any ore. Idle.

Bibl: California State Mining Bureau Bull. 95, p. 130.

Bismark Mine (see Calico-Odessa Mining Company).

Black Foot-Golconda Group of Mines. This group comprises 22 claims, situated in Sec. 13, T. 10 N., R. 1 E., S. B. M., in the Calico Mining District, 3 miles northwest of Yermo, a station on the Union Pacific Railroad. Elevation 2700 feet. Owner, J. R. Lane, Calico, California.

The formation is rhyolite tuff and breccia. Chlorides and chlorobromides of silver occur in irregular fractures and joint planes along the Golconda-Black Foot fault. The course of this fault is northwest and southeast, dip 50° southwest. On the Black Foot Claim there is a mineralized zone extending over quite an area, which is in the form of an impregnated deposit, similar to the deposits found on the Humbug Claim. Workings consist of shallow shafts and open cuts. Idle.

Bob Lee and Hattie Groups are in the Ivanpah District. They have long been idle.

Bibl: State Mineralogist's Report XV, p. 826.

Bonanza King Mine is a well known old producer in the Trojan District of the Providence Mountains. It is on the eastern slope of these mountains, about 25 miles east of Fenner, a station on the Santa Fe Railroad. Elevation 4200 feet. Idle.

For detailed description see Report XVII, pp. 360–361.

Bibl: State Mineralogist's Reports X, p. 532; XIII, p. 606; XV, p. 827; XVII, pp. 360–361; XX, p. 198.

Bray and Bisbee (*Rand Silver King Mining Company*). This property is in the Randsburg District, adjoining the California Rand Silver and Coyote properties, on the south. It was developed by a 1½-compartment shaft, to a depth of approximately 600 feet and by about 5000 feet of drifts and crosscuts distributed between four levels. Some ore was encountered. Idle.

For a detailed description see California State Mining Bureau Bull. 95, pp. 131–132.

Bonanza King Mine, Trojan Mining District, Providence Range of Mountains, San Bernardino County.

Bullion Mine, consisting of 12 claims, is in the Bullion Mining District, on the east slope of the Ivanpah range of mountains, 10 miles north of Cima. It is just east of the New Trail Gold Mine. Elevation 4500 feet. Owner, Joseph Johnson, Cima, California.

It is an old property. The ore consisting of carbonate of lead, carrying silver values, occurs in fractures in the limestone. Development consists of a shaft 150 feet deep. Idle.

Calarivada Mine. (See under Cooper.)

Calico-Odessa Group of Mines. This group of mines consists of a number of former producing properties known as the Baltic, Bismark, Garfield Odessa and Thunderer groups, consolidated under one owner-

ship, known as the Calico-Odessa Mining Company: J. R. Lane, president; F. J. Dawson, secretary; Ralph Roseberry, vice president and consulting engineer; E. W. Carroll, superintendent. Offices, 612 I. W. Hellman Building, Los Angeles.

The holdings of the company comprise 55 claims, totaling 1000 acres, situated in Secs. 10, 11, 14, 15 and 23, T. 10 N., R. 1 E., S. B. M., in the Calico Mining District, 5 miles northwest of Yermo, a station on the Union Pacific Railroad. Elevation 2500 to 2800 feet.

Bismark Group is situated on the divide between Bismark Canyon and a branch of Wall Street Canyon. The formation is rhyolite tuff. Chlorides and chloro-bromides of silver occurring in irregular fractures and joint planes in a mineralized zone along a fault fissure, known as the Bismark fault the course of which is N. 17° W., dip 30° W., separates a mass of brown tufa on the west from a light, stratified tufaceous sandstone. The ores of the Bismark Group are cerargyrite and a little chrysocolla, occurring in a gangue of barytes.

Development consists of shaft 100 feet deep and a series of open cuts and tunnels.

Garfield and Thunderer Group is situated on ridge west of Odessa Canyon. The divide between Bismark and Odessa canyons is mainly built up of massive violet-brown liperite. In this liperite occurs a series of ore deposits somewhat different from the Oriental and Silver King ore zones. The ore occurs in fractures and crushed zones of rock, usually cementing the fragments. These zones are connected with a distinct fault plane, known as the Garfield fault. The general course of this fault plane is northwest and southeast. Some ore was found along the main fault but the largest orebodies were on the south side of this fault. The whole forms a zone of irregular fissures in rhyolite tuff. The silver ores occur mainly on these cracks and seams and the whole often appears as a breccia of tuff, cemented by the gangue and argentiferous minerals. The argentiferous minerals are as usual cerargyrite and embolite; also a little chrysocolla, occurring in a gangue of barytes.

Development: At an elevation of 2800 feet is the lower Garfield tunnel which is 4000 feet in length, driven along the Garfield fault. At an elevation of 2900 feet is an upper tunnel about 2500 feet in length. Large chambers of ore were mined through these tunnels on both sides of the fault. These chambers were about 300 feet in length by 40 feet wide.

Odessa Mine is situated on a ridge west of Odessa Canyon, at an elevation of 2700 feet. The orebodies are found in bunches, or pockets, varying from small deposits to large ore chambers. Orebodies occur on intersections of fissures running in all directions through the rock mass. The fissures intersect Odessa fault which strikes N. 40° W., and dips 50° SW. Chlorides and chloro-bromides of silver are found along seams and fractures in the rock mass.

Development consists of the Odessa tunnel which is driven 600 feet on the Odessa fault. A number of winzes have been sunk from the tunnel level to depths of 100 feet on the vein. There are six miles of underground workings on the above-mentioned mines.


CLAIM MAP
OF
CALICO MINING DISTRICT
SHOWING CLAIMS THAT HAVE BEEN
CONSOLIDATED
SAN BERNARDINO COUNTY CALIF
SCALE
500 0 500 1000 1500 FT
COMPILED BY EDWARD L HAFF
WITH ADDITIONS BY W B TUCKER
DIVISION OF MINES
WALTER W BRADLEY
STATE MINERALOGIST
1930
9
10
11
13
14
15
16
21
22
23
24
Rhyolite Tuff & Breccia
Yellow Rhyolite Breccia
Rhyolite Tuff
Sandstone & Clay
Quaternary
Hornblende – Andesite
BURCHAM GROUP
LONE STAR GROUP
CALICO ODESSA MINING CO.
BLACKFOOT GROUP
DIETZMANN GROUP
ZENDA GOLD MINING CO.
EMPIRE SILVER LEAD M. CO.
STORM CLOUD
STORM CLOUD 1
STORM CLOUD 2
STORM CLOUD 3
STORM CLOUD 4
NORTH CALICO 3
NORTH CALICO 6
NORTH CALICO 2
NORTH CALICO 4
NORTH CALICO No 1
RED BLUFF 3
RED BLUFF No 4
RED BLUFF No 2
RED BLUFF
GREAT NORTHERN 4
CLARIA M.
HILL TOP
SWEET WATER
GIFT
GIFT FRACTION
LEXINGTON
BIRDS EYE No 4
BIRDS EYE
BIRDS EYE 2
BIRDS EYE 3
LUCKY BOY
OLD ORIENTAL
WREN
SIOUX
LITTLE SIOUX
EDGAR
GOVENER SMITH
6039 ROSE
SPAR
RUN OVER
RUN OVER No 3
RED HILL
6067 EUPHRATES
BULLION FRACTION
MAIDEN No 1
BALLEST No 1
BALLEST No 2
MORNING STAR
EVENING STAR
LUCY LANE
LUCY LANE No 1
J.R. LANE No 9
J R LANE No 8
J R LANE No 3
J R LANE No 2
J R LANE No 5
J R LANE No 6
J R LANE No 7
J.R. LANE No 1
GOLCONDA
TRIANGLE
RICHMOND
2766 MOUNTAIN VIEW
2766 SNOW BIRD
BLACK BIRD
BELLVIEW No 2
ANDRAMEDA
2766 ALABAMA
OVERLOOK
MINESOTA
MISSISSIPPI
MISSOURI
CONSOLIDATED
ST LOUIS
OHIO
IOWA
WYOMING
COLORADO
VERMONT
NEW MEXICO
WISCONSIN
TENNESSEE
DAKOTA
KENTUCKY
NEBRASKA
INDIANA
6040 OCCIDENTAL No 4
ZENDA EXT
ZENDA EXT No 2
6040 GORDON
ZENDA EXTENSION No 3
6040 WALL STREET
6040 ZENDA No 1
6040 ZENDA No 2
6040 ZENDA No 3
6040 ZENDA No 4
6040 ZENDA No 9
6040 LUCILLE
6040 ZENDA No 5
6040 ZENDA No 6
ZENDA EXT No 4
ZENDA EXT No 5
6040 ZENDA No 7
ZENDA EXT No 6
6040 ZENDA No 8
ZENDA EXT No 7
2911 TRY
2888 MILWAUKEE
2877 MILLSITE LODE
EMPIRE
REPUBLIC
COMMONWEALTH
HOMOSO
JACK
RAINBOW
TANTALITE
To Daggett
T.10N R.1E. S.B.M.

At the time these properties were visited the company was making a survey of the different underground workings and also compiling a geological map of the area. On the completion of this survey and the map, the most favorable point was to be determined for location of the main working shaft for the exploration of the ore zones in depth.

Several men employed.

California Coeur d'Alene Mining Company's property, consisting of 34 claims, is on the north side of the South Fork of Lytle Creek on the southeast slope of the San Bernardino Mountains. It is approximately 22 miles northwest of Rialto. Elevation about 4500 feet. Owner, R. D. Foster, Trustee, 671 I. W. Hellman Building, Los Angeles.

The rocks exposed on the south side of the South Fork of Lytle Creek here, are granitic. On this property, which is on the north side of the canyon, three beds of crystalline limestone are exposed on the precipitous mountain side. These are separated by from 200 to 400 feet of felsitic intrusives. There is a series of irregular, replacement deposits of unknown extent, along fractures in the felsite, as well as on the limestone contacts. The strike is generally NW.-SE., dip to the east at low angles. Values are in silver, lead and zinc.

Development consists of opencuts, shallow shafts and one 350-foot tunnel, which cut a large flow of water in one of the fractures. No commercial bodies of ore have as yet been developed.

Three men are employed doing assessment work.

California Rand Silver Mine is in the Randsburg District, approximately 1½ miles southeast of the town of Randsburg and one-half mile west of Osdick, a station on the Kramer-Johannesburg branch of the Santa Fe Railroad. It originally consisted of 12 claims in Sec. 6, T. 30 S., R. 41 E., M. D. M., but later, as the result of various consolidations, notably that with the Coyote (the Randsburg Silver Mining Company), it either owned or controlled about 70 claims. Owner: Was owned and operated by the California Rand Silver Company until September, 1929, when it was taken over by the Consolidated Metals Company; H. W. Klipstein, president; H. W. Gould and Company, consulting engineers, 762 Mills Building, San Francisco; H. L. Gibson, L. F. Main, R. A. Hardy, of Pasadena; Gordon Cole, superintendent.

By reason of its importance as a producer for several years, this mine being the largest single producer of silver in the United States,[1] much has been written concerning this property. The reader is referred especially to Bulletin 95 of the California State Mining Bureau, 'Geology and Ore Deposits of the Randsburg Quadrangle,' from which much of the following has been taken.

On April 12, 1919, Jack Nosser and W. H. Williams discovered the outcrop of a silver-bearing vein on the Juanita claim. Assays from this outcrop gave 300 ounces of silver and 3 ounces of gold per ton. The company was then formed. Initial shipments from a hole on the shaft vein, 17 feet wide by 22 feet long and 75 feet deep, gave returns in excess of $300,000 from the smelter.[2]

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[1] U. S. G. S. Water Supply Paper 578, p. 30.
[2] Hulin, C. D., California State Mining Bureau Bull. 95, p. 109.

The first shipment was made on June 15, 1919. On December 15, 1921, a 100-ton flotation plant was put into operation. This was later increased first to 200 tons and then to 400 tons per day. Total production of this mine to date (July, 1930) amounts to approximately $16,000,000, of which about $4,500,000 was paid in dividends. Figures on the actual tonnage from which this total production came are not available. However, to April 1, 1924, the production record was as follows:

Shipping ore: 49,150.70 tons, having an average content of $4.97 in gold and 106.04 ounces of silver per ton. Milling ore: 177,074 tons, average $1.50 in gold and 19.12 ounces of silver per ton. From the Grady lease 18,222.30 tons, which averaged $6.16 in gold and 81.64 ounces of silver per ton. The gross value of this ore was $10,152,666.90.

Some idea as to the value of the ore as mined may be had from the fact that one stope on the Antimony vein, between the seventh and eighth levels, produced 20,084 tons, having an average value of $73.95 per ton, or a total value of $1,485,212. This stope was not over 200 feet long, less than 100 feet high, and it is reported that it is in places 65 feet wide. Also a block of 10,400 tons in the Grady lease, average width of 5 feet, gave returns of $87 per ton, a total of $904,800.

There are two systems of veins in the Rand schist on this property. One system has a NE.-SW. strike, the other N.-S. The dip is to the southeast and east, respectively. Near the surface they dip steeply, but flatten with depth. It was at the junction of these various veins that the larger orebodies were found.

The principal veins worked were the Antimony, Alpha, Footwall, Shaft and Williams of the northeast-southwest series and the Blanck, Frog, Treasure Box, Rourke, Jameson, No. 3 Stope, 518 and 330, Sill, Harrell, Cow Trail, Hughes, Grady Lease, Wark, Unnamed and Nosser veins of the north-south system.

The mine was developed and worked through three principal shafts and approximately nine miles of drifts and crosscuts. No. 1 shaft, inclined at an angle of 73°, is down to the eleventh level, a vertical depth of 661 feet; No. 2, which was the main working shaft, is down to the nineteenth level, a depth of 1442 feet. It is vertical. No. 6 shaft, vertical, is 870 feet deep.

Due to the low price of silver the present operators are doing very little development work. Their work is confined to removing pillars and slabbing the walls of old stopes where the former operators had left ore. Some ore has been developed by following narrow streaks of high grade in the various veins. In this manner a gross production of approximately $40,000 per month has been maintained for some months past. Of this monthly production, 300 to 350 tons averaging $75 (with silver at 45¢ per ounce) is shipped direct to the smelter. About 1500 tons per month is milled, having an average value of $12.

For history of its development, description of the plant, cost of production and other details, see references.

Bibl: State Mineralogist's Reports XVII, pp. 361–362; XIX, pp. 61, 98, 99, 167; XX, pp. 48, 49, 96; Bull. 95, pp. 110–121.

Carbonate Mine. This old property, in the Oro Grande District, is reported to have shipped 3 cars in 1929, while under lease to W. E.

King of Los Angeles. Reported net returns of $35 per ton on these shipments. Idle.

Bibl: State Mineralogist's Reports IX, p. 230; X, p. 527; XI, p. 361; XII, p. 263; XIII, p. 33.

Carbonate Hill Group, consisting of 8 claims, is in the Holcomb Valley District, in the San Bernardino Mountains, 43 miles east of Victorville. Elevation 7500 feet. Idle. For description see

Bibl: State Mineralogist's Report XVII, p. 362.

Carbonate King Mine is about 7 miles southwest of Roach, Nevada, 5 miles west of the Salt Lake City highway, and on the southwest slope of Ivanpah range of mountains. Consists of 6 unpatented claims. Elevation 5500 feet. Owners, M. W. H. Williams, county treasurer, San Bernardino County, and associates.

The mineralization, consisting of oxides of iron and manganese and lead carbonates, carrying silver, occurs along a fracture and in the bedding planes of a dolomitic limestone. Strike of the bedding planes is NW.-SE., dip 45° SW. Fissure strikes N. 20° E., dip vertical. The replacement along bedding planes takes place for a distance of approximately 25 feet each side of the fracture.

Development consists of a tunnel, driven N. 20° E., 500 feet. This tunnel is at the same elevation as the top of the mill. No ore was encountered here. At the face a raise was put up to connect with the workings above. Some 300 feet above is a tunnel driven northeasterly. At 60 feet above the portal a strong fissure was encountered. This was followed for a distance of about 100 feet and stoped to the next tunnel above; also a short drift to the northwest, following the ore in the bedding planes. The upper tunnel is about 150 feet above. It is now an open cut, the ore having been stoped to the surface. It is 100 feet long and 40 feet high at the face. The average width of the ore is from 3 to 4 feet. At the concentrates loading bin, near the top of the surface incline tram, there is a shaft which was sunk to a depth of 112 feet on 45° inclination.

The mill on this property consists of the following: No. 2½ Wheeling jaw crusher to crushed-ore bin; belt feeder to rolls, to double-deck vibrating screen (¼ and 10-mesh); each of the three products from these screens goes to a separate jig; tails from all jigs to waste; hutch product from the two coarse jigs to rolls, to vibrating screen; fines from screen and hutch from fines jig to 3 Overstrom tables; oversize from screen returned to rolls. Water is recovered by means of drag belts. Mill driven by 60-hp. Fairbanks-Morse semi-diesel engine.

A 2-inch pipe line from the old Ivanpah Mine, which is 8 miles south, delivers water by gravity to the mill. Idle.

Cave Springs Mining Corporation (*Imperial Lode Mines.*) The property of this company is in the Lava Beds District, 9 miles southwest of Lavic, a station on the Santa Fe Railroad. It consists of 3 patented claims, the Morning Star, Mammoth Chief and Desert Queen, and 8 claims held by location. Elevation about 4000 feet. Owner, Cave Springs Mining Corporation; W. W. Tucker, president, 1308½ Valencia street, Los Angeles.

This property is on the Imperial lode. This lode consists of a great branching fissure in quartz porphyry, varying in width from 4 to 18 feet and traceable along a bold outcrop for a distance of 8000 feet. For a description of the veins and old workings see Eleventh Report, pp. 349–354. Present activity is described under Imperial Lode Lease.

Bibl: State Mineralogist's Reports XI, pp. 349–354; XV, pp. 821–822; XVII, pp. 362–363.

Columbia Mine. It comprises 4 claims, situated in the Kelso Mining District, on the southwest slope of the Providence range of mountains, 5 miles southeast of Ames, a station on the Union Pacific Railroad. Elevation 4600 feet. Owner, Mrs. R. P. Greenleaf and V. E. Stockwell, Los Angeles.

Three parallel veins occur in quartz-monzonite; strike N. 70° E., dip 40° to 50° SE. The veins vary in width from 12 inches to 6 feet. The vein quartz is mineralized with pyrite, galena and spalerite, with gold and silver values. The ore is said to carry \$4 to \$8 per ton in gold, 20 to 53 ounces in silver, with 1% to 3% in zinc.

The property was under lease to J. G. Thorne of Los Angeles during 1926, who shipped 57 tons of ore to the U. S. Smelting, Refining and Mining Company of Salt Lake, Utah, which had an average value of \$28 per ton in gold and silver.

Developments consist of an incline shaft 320 feet deep, with drifts on the vein on 100, 200 and 300-foot levels. On the 300-foot level there is a crosscut 300 feet south, which cuts a parallel vein. A tunnel has been driven northeast 300 feet on this parallel vein. This vein has an average width of 4 feet and carries values in gold and silver. Some stoping has been done above the tunnel level, also underhand stope below the tunnel level. Recent ore shipments were extracted from this tunnel. Idle.

Bibl: State Mineralogist's Report XVII, p. 340.

Chicken Hawk was a prospect in the Randsburg silver belt.

Bibl: California State Mining Bureau Bull. 95, p. 132.

Commonwealth Group (see Randsburg Associated Mines, Inc.).

Coyote (see Randsburg Silver Mining Co.).

Cuve (see Rand United Mining Co.).

Daggett Reduction Company (see Fifteenth Report, pp. 824–826).

Death Valley Mine, comprising a group of 7 unpatented claims, is 3 miles east of Cima, a station on the Union Pacific Railroad. Elevation 4400 feet. Owner, J. Lee Strawn, Cima, California.

This property was discovered in 1906 by J. L. Bright of Kelso. In July of the same year, the Death Valley Mines Company, a Colorado corporation, took over and operated the mine until the close of 1907, when it became involved in litigation which was not cleared up until 1915. The present owner came into possession of the property at this time. His operations were conducted from 1917 to 1921, when it was shut down, except that the pumps were kept in operation until June 11, 1927. On this date the plant was destroyed by fire and the property has not again been active.

The mine is on a flat at the foot of the northeast slope of the New York Mountains and is easily accessible over a good road.

Two parallel veins have been found on this property. They are approximately 215 feet apart; strike NE.-SW., dip 45° SE. The hanging wall is diorite and the footwall is granite. The vein, as stoped, averages 4 feet in width. The ore below 60-foot level is argentite (silver sulphide) with small amount of galena. From surface to 60-foot level, the ore consisted of chloro-bromides of silver.

The property was developed by 2 shafts. The principal one, known as the Death Valley shaft, was sunk on an inclination of 45° to a depth of 400 feet. In the bottom it is wholly in diorite. Levels were driven at 100, 150, 200 and 400 feet. On the 150-foot level there is a drift 400 feet west and 200 feet east; on the 200-foot level there is a drift 300 feet west and one 230 feet east. The ore shoot which was stoped from the 200-foot level to the surface, was 400 feet long and had an average width of 4 feet. On the 400-foot level a crosscut was driven south a distance of 138 feet. A parallel vein 7 feet wide was encountered in this crosscut. Drifts were driven on this vein, east 125 feet and west for the same distance. Average value of this ore was as follows: Gold, 0.16 ounces, silver 17 ounces, lead 2.5%, zinc 1.5%, this being the average of 500 tons which was put through the mill. A 10-inch streak on the footwall carried higher values. This ore, sorted out and shipped, averaged gold 1.87 ounces, silver 67 ounces per ton.

Southwest of the Death Valley shaft, a distance of 1500 feet, is the Arcalvada shaft. This shaft was sunk on a 70° incline to a depth of 285 feet. At the 125-foot level there is a drift east 135 feet.

The average grade of the ore shipped from between the 200-foot level and the surface was: Gold 0.18 ounces, silver 75 ounces, lead 2.5%. Average of second grade ore, which was milled: Gold 0.09 ounces, silver 12 ounces. Average grade of the concentrates shipped: Gold 0.23 ounces, silver 110 ounces, 18 to 23% lead and 15% zinc.

Ore reserves now reported as follows: 500 tons on dump, averaging gold 0.10 ounces, silver 17 ounces, lead 1.5% to 2%; 6000 tons of second grade ore broken in the stopes; 2 blocks of ore between the 150- and 200-foot levels, 500 tons, average value, silver 35 ounces, gold 0.12 ounces. Total production to date $131,000, of which the original company produced $93,000 and the present owner $38,000.

The Death Valley shaft makes 45,000 gallons and the Arcalvada 30,000 gallons of water daily.

A concentration plant now on the property consists of the following: A 14-inch by 21-inch Blake-type crusher, elevator to Marathon rod mill; elevated to screens, 10-mesh; oversize returned to mill; screenings to cone classifier; coarse to Isbell concentrator; fines to double deck Deister table. Plant driven by electric motor. Capacity 30 tons per day of 24 hours.

There is a 6-room residence and a well-built camp which will accommodate more than 100 men. Idle.

Ellingford Nipton Group, consisting of 3 claims, is in the Clark Mountain, 10 miles northeast of Valley Wells. Idle.

Bibl: State Mineralogist's Report XX, p. 94.

Flat Tire Group is in the Randsburg District, north of the Big Four property.

It was prospected by the *Southern Mining and Milling Company* to a depth of 1560 feet by a 2½-compartment, vertical shaft. This shaft passed through the Rosamond formation into the schist at a depth of 1200 feet. Some crosscutting was done on the 1530-foot level without disclosing any orebodies of commercial value. Idle.

Bibl: California State Mining Bureau Bull. 95, p. 134.

Fox Lease (see Bull 95, p. 134).

Garfield and *Thunderer Mines* (see Calico-Odessa Mining Co.).

Garfield Lease property is in the silver belt of the Randsburg District, just southeast of the Belcher Extension.

It was prospected by a vertical shaft 300 feet deep, with levels at 85, 200 and 300 feet. Spotted values in gold and silver were encountered in the footwall vein.

The property was taken over under a working agreement by the *Monarch Rand Mining Company.* Idle.

Bibl: California State Mining Bureau Bull. 95, p. 135.

Grady and Sill Lease was a part of the California Rand Silver Mine. From a small block of ground just south of the original workings of the California Rand Silver Mine, this lease produced $1,599,-979.98 before it reverted to the owners.

Bibl: California State Mineralogist's Report XIX, p. 61; State Mining Bureau Bull. 95, pp. 117–118.

Ibex Mine or Arcturas (Lead, silver, zinc). It is in the Black Mountains, 16 miles southwest of Zabriskie and 6 miles north of Saratoga Springs. Elevation 1300 feet. Idle.

Bibl: State Mineralogist's Reports XV, pp. 821–822; XVII, p. 287.

Imperial Lode Mine (see Cave Springs Mining Co.).

Imperial Lode Lease, consisting of one patented claim, the Mammoth Chief, is on the Imperial Lode, in the Lava Bed District. Frank W. Orr, Newberry, California, is the lessor; *Cave Springs Mining Company* is lessee.

The Imperial Lode vein has been described by Storms in Report XI, pp. 351–354.

The old work done on this claim consists of several tunnels. One, near the east end of the claim, was driven 200 feet in a westerly direction on the hanging wall side of the vein. On the other side of the ridge, about 1000 feet west of this work, two tunnels were driven in an easterly direction. These are about 50 feet (vertically) apart. The upper one is in about 200 feet, while the lower one is only 150 feet long. These were also driven on the hanging wall side but in each crosscuts were run to the footwall, exposing 6 feet of broken and groundup quartz. This condition on the footwall side is, no doubt, due to the fact that the felsite dike here faulted the vein. Across the canyon to the west is another short tunnel driven west.

The present operators have confined their work to the footwall side of the vein, where it has been cut by the dike. The lead-silver streak on which this work has been done shows a width, varying from a few inches to 4 feet. The gangue is calcite, barite and some quartz (the last named very subordinate in amount.) The mineralization consists of lead carbonates, anglesite, wulfenite and bunches of galena, carrying silver values as high as 60 to 70 ounces. Their work, consists of open cuts and one 15-foot shaft on the ridge between the old tunnels; also a tunnel driven east from a point in the ridge about 50 feet above the upper tunnel of the old workings. This tunnel is now in some 40 feet and shows a high-grade streak from 6 inches to 2 feet wide. It will be continued in an effort to get under the 15-foot shaft, where the greatest width of high grade ore was encountered.

Equipment consists of 20-h.p. Chicago Pneumatic Tool Company semi-deisel engine belted to 10 by 10 National air compressor; 2 jack-hammers; blacksmith shop and 3 cabins.

Three men are employed driving the tunnel.

Bibl: State Mineralogist's Report XI, pp. 349–354.

Indian Trail Mine is on the north slope of a spur of the Avawatz Mountain, in T. 18 N. R. 3 E., S. B. M. The property consists of 4 claims, 22 miles northwest of Riggs, a station on the Tonopah and Tidewater Railroad. Elevation 2300 feet. Owner, Indian Trail Mining Company; C. E. Berekhart, president; N. K. Rondell, secretary, Los Angeles.

The mineralization occurs along each wall of a diorite dike. The dike has been intruded between alaskite and andesite porphyry; strike NW.-SE., dip 65° W.

It is developed by 200-foot shaft on 65° inclination. On the 50-foot level there is a drift N. 40° W., 200 feet. At 40 feet from shaft, a crosscut was driven north 27 feet and at 50 feet from the shaft, there is a crosscut south 20 feet.

About 2300 feet east of the camp there is a gold quartz vein. The walls are granite and diorite. Values of $20 per ton in gold are reported across a width of 6 to 8 feet. Idle.

Joburg Divide was a prospect just east of Johannesburg. Idle.

Bibl: California State Mining Bureau Bull. 95, p. 144.

Johannesburg Mining and Milling Company owned and developed the Silver King and Silver Moon properties in the Randsburg silver belt.

Bibl: State Mineralogist's Report XIX, pp. 61–62; Bull. 95, p. 142.

Kelly Mine (see California Rand Silver Co.).

Kelly Rand Extension Mining Company sunk a 625-foot shaft some 1500 feet northwest of the California Rand Silver Company's No. 1 shaft, in the Randsburg silver belt. Idle.

Bibl: California State Mining Bureau Bull. 95, p. 136.

Lead Mountain Mine, consisting of 640 acres, patented in Sec. 36, T. 10 N., R. 1 W., S. B. M., is 5 miles northwest of Yermo. Owner,

Lewis I. Buck. Under lease to *Pacific Minerals Company, Ltd.,* 337 Tenth street, Richmond, California.

For detailed description of this property see Report XX, pp. 199–200.

An attempt to concentrate this ore with jigs and tables in the company's crushing plant at Barstow is reported to have been unsuccessful. Idle.

Little Jack was a prospect in the Randsburg silver belt. Idle.

Bibl: California State Mining Bureau Bull. 95, p. 144.

Lizzie Bullock, is an old property in the Ivanpah District, about 20 miles northwest of South Ivanpah. Idle.

Bibl: State Mineralogist's Report XV, p. 826.

Lucky Jim Mine, consisting of 5 claims, is in the Old Woman Mountains, T. 1 N., R. 21 E., S. B. M., about 20 miles north of Milligan, a station on the Parker cut-off of the Santa Fe Railway. Elevation about 2700 feet. Owner, E. J. Morath, 521 Walnut street, Long Beach, California. Under lease to F. A. Crampton, on the property.

Quartz vein accompanies a porphyritic dike in granite. As is usual in this type of vein, the lenses are found on either wall of the dike and probably overlap. Strike is N. 65° W., dip about 85° N. The vein is reported to average 4 feet in width. The vein matter is a vitreous quartz. Minerals observed were chlorides and bromides of silver and chalcopyrite. Occurrences of argentite and ruby silver are reported, but none were seen. The principal values are in silver. Shipments aggregating approximately $35,000 in value have been made since the opening in 1911. These shipments of selected ore are reported to have run from 200 to 400 ounces in silver, $3 to $4 gold, 5% copper and 5% lead.

The principal development consists of 500-foot crosscut tunnel, driven north. This tunnel is connected with the surface by means of an old shaft 200 feet deep. Considerable work and some stoping was done from this shaft above the tunnel level. The old workings are no longer accessible. On the tunnel level a drift has been driven west about 200 feet and east for a distance of about 150 feet from the crosscut. At the south end of the crosscut a winze 85 feet deep has been put down. Another winze has been sunk to a depth of 35 feet at a point 150 feet west of the crosscut, and 15 feet west of this winze there is a 100-foot raise. As stoped the ore shoots appear to have been from 75 to 100 feet long.

Equipment consists of a compressor driven by tractor engine; drills; Little Tugger hoist at the 35-foot winze; blacksmith shop; and 3 cabins. A three-mile pipeline brings water to the camp from a spring.

Three men are employed sinking the 35-foot winze. The present operator is directing his efforts toward the development of sufficient ore to warrant the erection of a mill.

Mizpah-Montana Property, comprising 2 fractional claims, is $1\frac{1}{2}$ miles southeast of Randsburg and 1500 feet northwest of the California Rand Silver Company's No. 1 shaft.

It was prospected by a $1\frac{1}{2}$-compartment shaft to a depth of 700 feet and some 1300 feet of horizontal workings.

For detailed description see

Bibl: State Mineralogist's Report XIX, pp. 167–168; Bull. 95, p. 138.

Mizpah-Nevada Property was a prospect on the San Bernardino-Kern County line, 1½ miles southeast of Randsburg.

Bibl: State Mineralogist's Report XIX, p. 168; Bull. 95, p. 138.

Mohawk Mine, consisting of 8 claims, is on the west slope of Mohawk Hill, 24 miles north of Cima, a station on the Union Pacific Railroad. Elevation 4500 feet.

Lead ore, having a total value of $70,000, was shipped from this property in 1917.

Bibl: State Mineralogist's Report XVII, p. 363.

Moon Leasing Company (see Johannesburg Mining and Milling Co.).

Morongo Mine is an old property in the Bear Valley Mining District. It consists of one patented claim and a mill site. It is at Cactus Flat. Elevation 5000 feet. Owner, I. E. Nichols, Building Materials Credit Association, 122 East Seventh street, Los Angeles.

The property is developed by 4 shafts, each about 100 feet deep. These were sunk on an east-west vein, carrying lead-silver ores. Idle.

Bibl: State Mineralogist's Report VIII, p. 503.

Mowry Mines Company (formerly known as *Gladstone Gold Mine* or *Halberg's Gold Mine*), consisting of 12 claims, is in the Lava Bed District, 9 miles southwest of Lavic, a station on The Atchison, Topeka and Santa Fe Railroad. Geographically it is the western extension of the Imperial Lode District. Owner, Mowry Mines Company; Roy M. Mowry, president and general manager; Roy N. Bunker, secretary, 2852 Florence avenue, Huntington Park, California.

The geology and ore bodies of this property have been described by Storms in Report XI, pp. 358–359.

There is some 2200 feet of development work on these claims. Four shafts, none of which are now accessible, are reported to have been put down as follows: No. 1, 85 feet deep; No. 2, 250 feet deep, with levels at the 50, 100, 150 and 250-foot horizons; No. 3, 175 feet deep; No. 4, 100 feet deep. Two tunnels 105 feet and 310 feet long, respectively, with a 50-foot winze in the latter, are also reported. This work, presumably all on the same fissure, is scattered over some 3000 feet of its length.

The present work is in No. 1 shaft. This shaft has a bulkhead in it at the 25-foot level. It is reported that the vein in the bottom is 4 feet wide and that values in gold, silver and lead average $22.50 per ton. The mineralization consists of copper oxides, cerussite and galena, carrying silver and free gold. On the 35-foot level a drift 20 feet east is reported to show 7 feet of ore in the face.

Equipment consists of 6-inch by 4½-inch Rix air compressor, driven by a gas engine; 4 jackhammers; blacksmith shop and camp.

There is on the ground, but not yet erected, the following milling machinery: Small jaw crusher; No. 3 Herman ball mill, 2 Plat-O tables;

2 classifiers; 2 vibrating screens; 3 Allen cone classifiers; a 44-h.p. Pacific marine semi-diesel engine and a 10-h.p. Fairbanks-Morse gas engine.

The present operators intend to continue the development of ore in their No. 1 shaft and will then erect and operate mill. They expect to obtain a water supply from their No. 2 shaft. At present, they are sinking a well for domestic water supply in the canyon at the camp. Four men are employed.

Bibl: State Mineralogist's Report XI, pp. 358–359.

Myra Queen Group (see Randsburg Associated Mines, Inc.).

Navajo and Swastika Mines (Grady No. 2 and No. 1). See California State Mining Bureau Bull. 95, p. 139.

Odessa Mine (see Calico-Odessa Mining Company).

Oriental Group (see Zenda Mining Company).

Oro Plata Mine, consisting of 7 claims in Secs. 23 and 26, T. 3 N., R. 19 E., S. B. M., is in the Old Woman Mountains, 19 miles north of Milligan, station on the Parker cut-off of The Atchison, Topeka and Santa Fe Railroad. This property is just south of the Lucky Jim. Owner, A. F. deSteiger, Danby, California.

There is a series of parallel veins associated with quartz-porphyry dikes in granite; strike N. 65° W., dip 65° S. They are from a few inches to 5 feet in thickness. The gangue is a vitreous quartz, mineralized with chloro-bromides of silver, galena and free gold.

Development consists of 4 shafts, 30, 56, 76 and 170 feet deep, respectively, and open cuts distributed over some 1200 feet of length along the vein. Several cars have been shipped with reported net smelter returns of $95 per ton. All of this ore came from within 75 feet of the surface.

Idle, except for assessment work.

Perseverance Mine, comprising 12 claims, is in the Trojan District, 22 miles northwest of Fenner, a station on the Santa Fe Railroad. It is in the Providence range of mountains, northeast of the Bonanza King Mine. Idle.

Bibl: State Mineralogist's Report XVII, pp. 364–365.

Pilot Group (see Frisco Group, under Gold).

Providence Mine, now comprising one claim, is in the Providence Mountains, 7 miles east of Hayden. It adjoins the Frisco Group of gold claims on the south. Elevation 5200 feet. Owner, Pete Thibedeau, on the property; address, Kelso, California.

A shaft was sunk 300 feet on the contact of limestone and diorite, with some drifting on the 100 and 200-foot levels. Sixty-five feet below the collar of the shaft a tunnel was driven east 200 feet and connected with the shaft. Drifts off this tunnel were driven north and south for several hundred feet along a fracture which was filled with gouge. None of this work disclosed any ore.

Equipment consists of 350-cu.ft. Chicago pneumatic air compressor and gas engine hoist.

Idle since 1926.

Rand Contact Property, a prospect in the Randsburg District, just south of the Black Hawk. Idle.

Bibl: State Mineralogist's Report XIX, p. 168; Bull. 95, p. 140.

Rand Mountain Property, a prospect in the Randsburg silver belt, prospected by a vertical shaft 435 feet deep.

Bibl: California State Mining Bureau Bull. 95, p. 140.

Randsburg Associated Mines, Incorporated, held 4 groups of claims in the Randsburg silver belt. These groups were the *North Rand* and *Myra Queen,* north of Red Mountain; the *Silver Queen Group* of 3 claims lying between the Flat Tire and Big Four shafts; and the *Commonwealth Group* of 2 claims lying northeast of the Silver Queen Group.

Bibl: California State Mining Bureau Bull. 95, pp. 140–141.

Randsburg Silver Mining Company (Coyote) was eventually consolidated with the California Rand Silver (see, also, Wortley Consolidated Mines Company for the Santa Fe Mine).

Bibl: California State Mining Bureau Bull. 95, pp. 133–134.

Rand Silver Mining Company (see Bray and Bisbee).

Rand United Mining Company prospected 6 claims in the Randsburg silver belt, through the Mizpah-Montana shaft. Idle.

Bibl: California State Mining Bureau Bull. 95, pp. 134–138.

Santa Fe Mine (see Wortley Consolidated Mines Company).

Silver Basin Mine (see Elkhorn Mining Company, under Gold).

Silver Bell Development Company has 8 claims in the Lava Bed District, 17 miles southeast of Newberry Springs and 29 miles east of Daggett. Owner, Silver Bell Development Company; C. H. Bellamy, president and general manager; Maude Gilmore, secretary, 928 West 101st street, Los Angeles.

The mountain on which these claims are located consist of a series of basic volcanic flows, capped by some 200 feet of rhyolite. They dip to the west at an angle of from 20° to 30°. The separate flows are from 250 to 400 feet thick and the texture varies from vesicular, at the contacts, to granitoid in the center of the thickest flows. These formations are traversed by a series of roughly parallel fault fractures, strike N. 40° W., dip 60° to 80° NE. Seven of these have been found on the property. Where these fractures cross the contacts, the vesicles have been filled with green and white calcite, forming amygdaloidal beds. These amygdules apparently exist for only a few feet on each side of the fracture. The fault fractures are from 2 to 5 feet wide and are entirely filled with calcite. There is one exception in the case of a vein, strike N. 35° W., dip 80° E. The hanging wall is andesite and the footwall is diorite. This vein is 7 feet wide, the filling consists of 9 inches of red, sticky clay on each wall, 2½ feet of well cemented rhyolite tuff and 3 feet of clay and rhyolite boulders, mixed. The filling suggests that this may be a vent through which the rhyolite cap-

ping ascended. Values in gold, silver and lead are reported to exist in these veins but no metallic minerals were observed.

Development consists of a crosscut tunnel, driven south for a distance of 435 feet. At 95 feet from the portal there is a drift 17 feet W. and 67 feet E. At 165 feet from the portal the crosscut connects with a 53-foot shaft from the surface. At this point there is also a drift 15 feet east. At 400 feet from the portal, a 100-foot winze has been sunk on the 'red mud' vein described above. At this depth a small flow of water was encountered.

Equipment consists of Schramm compressor; 3 drills; blacksmith shop; and camp.

A small, experimental mill was erected at Ladd's Road House, 6 miles northwest of the mine. It consists of a 6-inch by 9-inch jaw crusher; ten 20-lb. spring stamps and a service concentrator. Power is furnished by 15-h.p. Universal distillate engine.

Three men are employed sinking winze.

Silver Belle Mining Company prospected 3 claims adjoining the California Rand Silver Company's holdings on the west. Idle.

Bibl: State Mineralogist's Report XIX, p. 169; Bull. 95, p. 141.

Silver Cliff Mine, comprising 19 claims, is in the Lava Bed District, 18 miles east and south of Newberry Springs and 8 miles south of the Needles highway. It is one mile east of the Silver Bell. Owner, Silver Cliff Mining Company; Frank A. Humphrey, president and general manager, Box 4, Newberry, California, or 818 Chester Williams Building, Los Angeles. Main office, 19–20 Dover-Green street, Dover, Delaware.

Here a bed of crystalline limestone, dipping to the south is traversed by a northwest-southeast and a north-south fracture. At their intersection the limestone is badly brecciated. The ore forms along the fractures and in the loosely cemented breccia, at the intersection. Values are in lead and silver but no idea of average values were obtainable, nor could any metallic minerals be identified in the ore.

Development consists of a vertical shaft 376 feet deep and a 150-foot shaft sunk on a 75° incline. These are connected on the 150-foot level. Levels in the 376-foot shaft were driven as follows:

One hundred-foot level—crosscut south 15 feet; 150-foot level—drift W. 35 feet; drift E. 200 feet; 160 feet east of shaft there is a crosscut south 45 feet; north 90 feet to bottom of 150-foot incline; 15 feet south of incline is a drift east 25 feet (all of this work is drifting, part on the NW.-SE. and part on the N.-S. fracture). Two hundred fifty-foot level: crosscut N. 25 feet; drift 6 feet E., 8 feet W. Three hundred fifty-foot level: crosscut 75 feet N. This crosscut is wholly in andesite, which apparently cuts off the limestone. No vein was encountered on this level.

An 80-foot shaft on Vanadium No. 3 claim, other shallow shafts and short tunnels complete the development work.

A small mill was erected on this property. It consisted of Wheeling jaw crusher; 4-foot by 4-foot Denver Engineering Works ball mill; Atkins classifier; ore flotation cell; 2 service concentrators; one 8-foot and one 4-foot dewatering cone.

Water was obtained through a 2½-inch pipe line from a well in the flat 6 miles north of the mines. Idle.

Silver Giant Property was a prospect on Red Mountain in the Randsburg District. Idle.

Bibl: California State Mining Bureau Bull. 95, pp. 141–142.

Silver Glance Property is on the western slope of Red Mountain in the Randsburg silver belt. It is reported that the Wortley Consolidated Mines Company has taken it over.

Bibl: State Mineralogist's Report XIX, p. 169; Bull. 95, p. 142.

Silver King Property (see Johannesburg Mining and Milling Co.)

Silver King Mine (Olivier-Frank Osborne Company. See Zenda Mining Co.). It is in the Calico District.

Silver King Mine, consisting of 6 claims, is in Clark Mountain, in T. 18 N., R. 13 E., S. B. B., 10 miles northeast of Valley Wells. Idle.

Bibl: State Mineralogist's Report XX, p. 94.

Silver King Mine, consisting of 7 claims, is in the Providence Mountains, about 25 miles northwest of Goffs. It adjoins the Bonanza King on the south. Owner, Jens W. Yonggren, 720 West 59th place, Los Angeles. Under lease to H. E. McKnight, 840 South Flower street, Los Angeles.

It is reported that a shaft has been put down to a depth of 165 feet on this property. Also that this work has disclosed a vein from 4 to 6 feet wide which carries from \$10 to \$56 per ton in lead, silver and gold. No further information available. Presumably idle.

Silver Lode and Black Water Mines, comprising 4 claims, are in the Resting Springs District, on the northeast slope of the Kingston range of mountains, 17 miles west of Ripley, Nevada. Idle.

Bibl: State Mineralogist's Report XVII, p. 366.

Silver Moon Property (see Johannesburg Mining and Milling Co.).

Silver Queen Group (see Randsburg Associated Mines, Inc.).

Silver Reef District (see Report XV, pp. 828–829).

Silver Rule Mine is in the Resting Springs District on the southwest slope of the Kingston Mountains, 17 miles east of Morrison's Siding on the Tonopah and Tidewater Railroad. It consists of 5 claims at an elevation of 4800 feet. Owner, *Pacific Lead and Silver Co.,* Foreman and Clark Building, Los Angeles. Idle.

Bibl: State Mineralogist's Reports XVII, pp. 365–366; XXII, p. 500; XV, p. 104.

Silverton Group, consisting of eleven and a fraction claims, is about 2 miles southwest of the Rand Contact property, in the Randsburg silver belt. Idle.

Bibl: California State Mining Bureau Bull. 95, p. 143.

Snow Storm Mine is in the Clark Mountain District, 12 miles northeast of Valley Wells. It consists of 4 claims. Idle.

Bibl: State Mineralogist's Report XX, p. 94.

Stonewall Mine is in T. 18 S., R. 13 E., S. B. M., in the Clark Mountain District, about 12 miles northeast of Valley Wells. It comprises 15 claims. Was extensively worked from 1881 to 1896. Idle.

Bibl: State Mineralogist's Reports XV, p. 826; XX, p. 94.

Tip Top Mine is an old property in the Lava Bed District, just south of the Imperial Lode. It is about 10 miles south of Lavic, a station on the Santa Fe Railroad. It was quite a producer of silver-copper ore forty years ago. Idle.

Bibl: State Mineralogist's Report XI, pp. 354–358.

Total Wreck Mine (Burcham Group). It comprises 15 claims situated in Secs. 15, 16, 21 and 22, T. 10 N., R. 1 E., S. B. M., in the Calico Mining District, 4 miles northwest of Yermo, a station on the Union Pacific Railroad. Elevation 2300 feet. Owner, Mrs. Rosella Burcham, Pasadena, California. Under option to Judge Towhy Estate, Los Angeles; James Horn of Los Angeles, resident manager; M. R. McKay, superintendent.

The mud shales and argillaceous sandstones here lie nearly horizontal and contact with tufaceous breccia or yellow-colored rhyolite on the northwest. There are two veins. One has a course of N. 40° W., dip 70° S., and is known as gold vein. The other vein strikes E. and W., dip 70° S., and is known as the lead vein. The veins are composed principally of coarsely crystalized barytes, with quartz, containing brown iron oxides, lead carbonate, manganese oxide and chloride of silver. The veins vary in width from a thin seam to over 10 feet in width, with an average width of 3 to 4 feet.

Development consists of crosscut tunnel 500 feet long. This tunnel level at 125 feet from the portal cut the lead vein, with drift west on this vein 1300 feet and east 200 feet. The vein has an average width of 4 feet and is said to average 10% lead, 10 ounces in silver, with $2 to $4 per ton in gold. The crosscut tunnel continues in a northerly direction for about 270 feet, where it cuts the contact of the stratified sandstone and tufaceous breccia. On this contact occurs the gold vein, which is an iron-stained brecciated quartz, from 8 inches to 3 feet wide. A drift has been run 400 feet east on this vein. This vein is said to carry from $4 to $8 per ton in gold. About 1500 feet north and at an elevation of 500 feet above the tunnel level, an incline shaft has been sunk on a vein to a depth of 80 feet. This shaft developed an orebody 20 feet in width. The ore is said to carry 10% lead, 4 ounces in silver and $4 per ton in gold. The east and west vein which was cut in the tunnel level has been stoped east to the surface for a distance of 100 feet and for a width of 12 feet.

Shipments of ore made from the above-mentioned workings are said to average $9 per ton in gold, 13 ounces in silver and 36% in lead. Ninety tons of ore had been shipped from the property at the time of visit.

Equipment consists of loading bins; jig-back tram line from upper workings to bin; blacksmith shop and office building.

Four men are employed.

Bibl: State Mineralogist's Reports XI, p. 343; XVII, p. 351.

U. S. Mine is in T. 18 N., R. 13 E., S. B. M., in the Clark Mountain District, 12 miles northeast of Valley Wells and 17 miles northwest of Nipton, Nevada. Holdings consist of 4 claims. Idle.

Bibl: State Mineralogist's Report XX, pp. 94–95.

Valentine Group, consisting of 14 claims, is located on the western slope of Clark Mountain, in T. 17 N., R. 13 E., S. B. M., 5 miles northeast of Valley Wells and 23 miles north of Cima, a station on the Union Pacific Railroad. Elevation 6500 feet. Owner, Louis E. Keiper, Cima, California. Under option to *Pacific Foundation Corporation;* T. J. Howard, president; Albert Whittle, secretary, San Diego, California.

Bibl: State Mineralogist's Report XX, p. 95.

War Eagle Mine is located on the eastern slope of the Lead Mountains in T. 4 N., R. 10 E., S. B. M., 9 miles south of Bagdad, a station on the Santa Fe Railroad.

Property is now controlled by H. LeRoy Blessing, 4992 Melrose avenue, Los Angeles, California. Holdings consist of some 320 acres. Development consists of a 700-foot shaft and some 7000 feet of drifts and crosscuts.

Blessing and his associates plan to reopen this property in the very near future. They are especially interested in the recovery of the molybdenum and vanadium which are associated with the lead.

For full description of the property and development work, see,

Bibl: State Mineralogist's Reports XVII, p. 336; XX, pp. 95–96.

Waterloo Mine. It comprises 9 claims located in the Calico Mining District, in Sec. 16, T. 10 N., R. 1 E., S. B. M., 4 miles northwest of Yermo, a station on the Union Pacific Railroad. Elevation 1900 to 2180 feet. Owner, O. F. Washburn, Anaheim, California. This property was formerly owned and operated by the Waterloo Mining Company, Milwaukee, Wisconsin.

The Waterloo and Silver King mines were operated by the above-mentioned company from 1881 to 1896. The principal orebodies occur along the Waterloo fault, which strikes northwest and southeast and dips 40° S. The orebodies mined and developed along this fault were found in bunches to very large chambers of ore from 10 to 80 feet in width. The orebody was 1100 feet in length and extended to a depth of 525 feet. The ore is chlorides and chloro-bromides of silver, in a gangue of barite and jaspery silica.

Development consists of two tunnels, the lower tunnel being 1500 feet in length. Upper tunnel is 290 feet in elevation above lower tunnel and is 600 feet in length. There is also an incline shaft 350 feet deep.

Drifts on vein.

Upper tunnel	600 feet
No. 1 level	650 feet
No. 2 level	500 feet
No. 3 level	690 feet
No. 4 level	200 feet

Idle.

Bibl: State Mineralogist's Reports VIII, p. 498; XI, p. 343; XII, p. 376; XIII, p. 609.

Waterman Mine. It comprises 5 patented claims situated in the Grapevine Mining District, 4 miles north of Barstow. Owner, Mrs. W. M. Waterman, Barstow, California.

The formation in which the vein occurs is a rhyolite tuff. The vein is 4 feet wide.

Development consists of a shaft 350 feet deep. The orebody has been worked for the full length of the Waterman claim. There was a 10-stamp mill on the property and the ore milled is reported to have averaged $20 per ton in silver. The property is reported to have had a production of $4,000,000. There are 40,000 to 60,000 tons of tailings on the property reported to have an average value of 5 ounces in silver.

These tailings are under lease to Cooper Shapley and Charles Hook of Los Angeles, who have installed 125-ton flotation plant to recover the barite in the tailings. The tailings are reported to contain 25% $BaSo_4$. Four men employed.

Bibl: State Mineralogist's Reports X, p. 531; XIII, p. 609.

Wortley Consolidated Mines Company (formerly *Great Western Mining and Milling Co.*) This company owns or controls several groups of claims in the Randsburg silver belt. The most important of these are: The California Rand Silver Company's property (quite recently acquired), the Santa Fe Group and the Silver Glance Group. Below is given a description of the Santa Fe only, for others see under names of the various properties.

The Santa Fe Group comprises 15 claims and is in the town of Osdick, on the Kramer-Johannesburg branch of the Santa Fe Railroad. It adjoins the California Rand Silver property on the northeast. Owner, Wortley Consolidated Mines Company; C. C. Wortley, president, 502 North Brand boulevard, San Fernando, California; A. W. Ham, secretary, Las Vegas, Nevada.

The northeast-southwest and north-south fissures of this district traverse the Rand schist on this property. It is believed by the operators that the Antimony and Williams (?) veins, so extensively worked in the California Rand Silver Mine, have been encountered in their workings. Also a vein which has been called the Schist vein. This latter vein has great width, in places as much as 80 feet. These veins are similar to the veins of the California Rand Silver Mine, in that the schist is mineralized along the two systems of fracturing. Vein filling consists of silicified schist, quartz and brecciated schist, recemented with quartz. The mineralization consists of antimonial sulphides of silver, pyrite, chalcopyrite and stibnite. The widths of the veins vary from about 2 to 80 feet.

The principal development consists of the Santa Fe shaft. This shaft is vertical and is 1200 feet deep. To the 935-foot level it is 1½-compartments, below this level it is 2½-compartments. The Rand schist was first encountered at a depth of approximately 850 feet. Levels were driven at the 935, 1000, 1100 and 1200-foot horizons. The total underground development at this shaft is 7575 feet. The Antimony vein was first encountered on the 935-foot level about 100 feet northwest of the shaft. It crossed the shaft between the 1000 and 1100-foot levels and has been crosscut on each of the levels. Its width varies from 12 to 30 feet. The Schist vein has been crosscut on the 1000, 1100 and 1200-foot levels; it varies from 12 to 80 feet in width, and according to Mr. C. W. Mitchell, E.M., it averages 19.36 ounces of silver and 0.13 ounces of gold.

The amount of development work done on the veins at the various levels is as follows:

Antimony Vein

935-foot level—Crosscut showed a width of 20 feet.
1000-foot level—200 feet of drifting; average width 15 feet.
1100-foot level—225 feet of drifting; average width about 18 feet.
1100-foot level—Raise about 125 feet to 1000-foot level.
1200-foot level—Crosscut showed a width of 38 feet.

Schist Vein

(This vein was encountered on the 1000-foot level.)
1000-foot level—150 feet drifting; average width about 20 feet.
1100-foot level—100 feet drifting; average width about 12 feet.
1200-foot level—200 feet drifting; average width unknown.
Raise about 120 feet from 1100-foot to 1200-foot level.
Raise about 120 feet from 1000-foot to 1100-foot level.

Williams (?) Vein

935-foot level—350 feet drifting.
1000-foot level—100 feet drifting.
(It has not been definitely identified below this level.)

There are several other smaller veins that have been encountered in crosscuts on the various levels.

A drift has been driven some 700 feet southwesterly and an incline raise here put up to hole the bottom of the No. 6 shaft of the California Rand Silver Mine.

Equipment at the mine consists of 50-h.p. single-drum hoist, motor driven; 12-inch by 10-inch Ingersoll-Rand air compressor, driven by a 60-h.p. motor; 14-inch by 12-inch Chicago pneumatic air compressor, driven by 100-h.p. motor; 3 Byron-Jackson Multiplex pumps, each driven by 30-h.p. motor. The pumps are installed on the 1200, 900 and 600-foot levels; each has a capacity of 200 gallons per minute. There is also a blacksmith shop and assay office.

The mine makes 15,000 gallons of water daily. This water has recently been used in the California Rand Silver Company's mill.

Four men are employed driving a raise from the 1200 to 1100-foot levels.

Zenda Gold Mining Company, T. H. Collins, president; W. F. Stanton, secretary; Jack Radcliffe, superintendent. Offices, 517 I. W. Hellman Building, Los Angeles. This company owns the Oriental and Silver King group of mines, comprising 35 claims, situated in Secs. 15 and 22, T. 10 N., R. 1 E., S. B. M., in the Calico Mining District, 3½ miles northwest of Yermo, a station on the Union Pacific Railroad. Elevation 2500 to 2600 feet.

There are two systems of veins on the property known as the Oriental and Silver King fissures, which occur in rhyolite tuff, along what is known as the Kings system of fault fractures. The Oriental vein intersects the Silver King vein near the southeast corner of the Silver King claim. The vein system strikes northwest and southeast and dips 70° SW. Towards the southern end of the system considerable fault-

Steel headframes and hoist house of No. 2 shaft. Zenda Gold Mining Company, Calico, San Bernardino County.

ing has followed the fracturing, while at the northern end of the system the deposits occur as typical fissure veins with well-developed walls. Along this system of fault fractures the crushing of the rock and faultings reached its maximum on the Red Cloud and Red Jacket claims. Here the rhyolite tuff is in places completely disintegrated and brecciated; and barite and jasper are deposited in cracks and seams, running in all directions through the brecciated mass. The main ore deposits are connected with the main fault planes.

On the Silver King vein the dislocations have been large, resulting in step-faults with successively smaller throw. The ores found along these fissures are all similar in character. A gangue of barite and jaspery silica encloses more or less regularly chlorides and chlorobromides of silver. The cerargyrite and embolite mostly occur as thin coatings in joints and cracks, but also often embedded in the barite. The ore shoots are irregular and occur along the faults fissures, forming orebodies 20 to 50 feet in width. The Silver King vein system was

formerly worked through an incline shaft 500 feet in depth, also opened by a series of crosscut tunnels from the Oriental Mine on the fourth, sixth, seventh, eighth and ninth levels. There are about 6000 feet of drifts and crosscuts on the vein system.

The King and Waterloo mines were operated from 1883 to 1893 by the *Waterloo Mining Company.* In 1893 operations were suspended when silver declined to 78 cents per ounce. From 1883 to 1886, the mines produced 37,000 tons of ore, having a gross value of $1,355,000 or $36.61 per ton in silver; paid dividends of $450,000 or $12.16 per ton. Tailings loss was $7.32 per ton. Operating expense was $17.13 per ton.

The property was acquired in the latter part of 1926 by the Zenda Gold Mining Company. This company put down two diamond drill holes; one an incline hole, to a depth of 315 feet, which cut the Oriental vein. This hole is said to have cut 18 feet of ore with an average value of 8 ounces. The other was a vertical hole 500 feet in depth which encountered the Oriental vein at 455 feet and is stated to have cut 30 feet of ore having an average value of 15 ounces in silver.

From information obtained from these drill holes, No. 1 shaft was sunk to a vertical depth of 340 feet on the southeast end of Wall Street claim. On the 320-foot level a crosscut was driven northeast, in which it is stated 20 to 40 feet of ore was encountered, with an average value of 40 ounces in silver. Occasional bunches of sulphide ore were encountered on this level, showing chalcopyrite, tetrahedrite and pyrite, with high values in silver. Water was encountered at a depth of 300 feet, the flow being so great that pumps had to be installed. The present flow is 200 gallons per minute. In June, 1929, they started to sink a new 3-compartment shaft (4 feet by 6½ feet) (4 feet by 6½ feet) (4 feet by 4½ feet), which is located on the Oregon claim 547 feet southeast of No. 1 shaft. This shaft, which is known as No. 2 shaft, was sunk to a vertical depth of 550 feet. Drifts and crosscuts have been driven on the 320, 430 and 530-foot levels. The total amount of development from No. 2 shaft consists of 12,000 feet of crosscuts and drifts on the above-mentioned levels. Three crosscuts are being driven northeast on the 530-foot level to intersect the King vein. A drift on the 240-foot level connects with workings from No. 1 shaft.

The new development work has determined the present water level of the district and with the discovery of high grade bunches of ore on the 320-, 430- and 530-foot levels, mineralized with chalcopyrite, tetrahedrite and pyrite, indicates the possibilities of finding sulphide orebodies at greater depths on the King and Oriental vein systems.

The ore developed on the above-mentioned levels is stated to carry from 10 to 40 ounces per ton in silver, with some high-grade bunches carrying appreciable values in copper, with assays as high as 1000 ounces per ton in silver.

Mine equipment: Steel headframe, double-drum electric hoist, driven by 75-h.p. motor capable of hoisting to a depth of 4000 feet; 476-cubic-foot Ingersoll-Rand compressor, driven by 100-h.p. motor; Aldridge triplex pump, driven by 75-h.p. motor, capacity 500 gallons per minute; Pomona electric pump; blacksmith and machine shops.

Forty-seven men are employed.

Bibl: State Mineralogist's Reports VIII, pp. 491–498; IX, p. 224; X, p. 530; XI, pp. 337–344; XII, p. 376; XIII, pp. 606–607; XVII, pp. 359–366; Trans. Am. Inst. of Min. Engrs., Vol. XV, p. 718.

TUNGSTEN

Much information regarding the various tungsten districts in San Bernardino County may be found in Report XV, pp. 830–849. Also,

Steel headframe at Union Shaft, Atolia Mining Company, Atolia, San Bernardino County.

regarding the Atolia District, reference should be made to California State Mining Bureau Bulletin 95.

Argosy Mine, consisting of 3 claims, is in the Signal District, 6 miles north of Goffs.

The ore consists of fine crystals of wolframite, disseminated in a system of veinlets in a pegmatite dike.

Bibl: State Mineralogist's Report XV, pp. 844–845.

Atolia Mining Company. This property, consisting of some 60 patented claims, is approximately 3 miles southeast of Randsburg, on the Kramer-Johannesburg branch of The Atchison, Topeka and Santa Fe Railroad. Elevation 3200 feet. Owner, Atolia Mining Company; A. V. Udell, president and general manager; F. W. Bradley, vice president, 1022 Crocker Building, San Francisco, California.

Description of the district and its development through the year 1924 is contained in Reports XV and XVII and Bulletin 95 (see bibliography below).

The present work is confined to the Papoose, the ground between the Spanish shaft of the Par Mine and the Flat Iron, the Union Mine and the 'Spud Patch.'

The Papoose is under lease to Mr. Geo. Rust, who has reopened the old shaft to a depth of 400 feet. At present he is removing the fill from old stopes and will later look for extension of the orebody which was lost in the old workings. Drifts on the second and third levels have been opened as follows:

Second level 135 feet west of shaft and 65 feet east.

Third level 80 feet west of shaft and 40 feet east.

The filling is sorted, yielding about one ton of ore to 10 tons of material.

A section of ground between the Par Mine and the Flat Iron has been leased to E. H. Hughes, of Randsburg. A shaft has been sunk to a depth of 56 feet on a vein, the strike of which is east-west, dip 80° to the north. This shaft is 200 feet west of the Spanish shaft. This is the same vein as that worked to the east of the Spanish shaft but was apparently lost on the west side. At the bottom of the shaft, there is a drift east 25 feet and west 21 feet. This has developed an ore shoot 45 feet long, having an average width of 12 inches.

At the Union Mine a winze has been sunk from the 1000- to the 1200-foot level and the shaft was raised on a steeper inclination than that between the 700- and 1000-foot levels the dip of the vein being greater here. In doing this work, an ore shoot 1000 feet long by an average width of 3 feet, was developed. The average grade of the ore in this shoot is about 0.75% WO_3. It rakes to the east at an angle of about 55°. A stope has been started just west of the winze on the 1100-foot level.

The Spud Patch diggings now consist of a roughly circular pit about 500 feet in diameter, by an average depth of 15 feet. This pit will be lengthened in a northwesterly direction. There are at least two and probably more, channels in this area. After the present surface cut is made, these channels will be worked separately to greater depths. The placer is known to extend to the Papoose shaft, a distance of approximately 2000 feet, in a northwesterly direction from the present pit face.

The material is loaded into trucks by an Erie G A-2 gasoline shovel, having a 1-cu. yd. dipper.

The mill to treat this placer material was built in 1926. It has a capacity of 750 tons in 24 hours and consists of the following equipment:

Trommel screen 4 feet by 10 feet, 2-inch round openings. It is fitted with a shaft through its center, to which twelve 12-pound hammers are

attached by chains. This shaft travels at 350 r.p.m.; the hammers knock all loose material from the boulders, which go to waste. The screenings go to 4 Harz jigs, thence to 2 Overstrom tables. The tailings go to 4 dewatering drag belts; thence to 18-inch belt tailings stacker. This stacker is set on a slope of 3½ inches per foot. The stacker dumps on a 16-inch belt conveyor 20 feet long, pivoted so that its outer end swings through an arc of about 300°. Tailings are discharged at 12% moisture. Material treated averages 1.75 pounds concentrates, containing 60% WO_3 per ton.

The No. 1 (or Rust) mill was built at the Union Mine in 1927 and rebuilt in 1928. It was built by the Atolia Mining Company for the Rust Leasing Company. The Atolia Company took it over in September, 1928, upon the expiration of the Rust lease. The mill has a capacity of 130 tons per day and is working on ores from the Union Mine and various dumps on the company's property; also treating ores from the two leasers mentioned above.

Ores at the dumps are loaded into trucks by power shovels. Ore from the Union Mine is hoisted in 2250-pound skips. Material passes over bar grizzly, 3-inch opening; oversizes to 24-inch sorting belt; waste to 16-inch belt tailings stacker; ore to storage bin; undersizer to storage bin. From the bin it is fed by reciprocating feeder to 24-inch belt conveyor equipped with Ding's magnetic pulley; to 10-inch by 16-inch Hercules jaw crusher, crushing to 2 inches; elevated to Hummer screen; screenings to bin and oversize, by 14-inch belt conveyor to Symons 3-foot cone crusher, in closed circuit with Hummer screen, by means of elevator. The capacity of this crushing plant is 15 tons per hour, from 2 inches to ¼ inch.

Elevated from bin to vibrating screen oversize to Harz jig; undersize and hutch product from jig to Wilfley No. 4 and Overstrom tables; tailings to dewatering drag belts and 16-inch belt stackers. Slimes are settled in surface ponds. Concentrates are retreated in a plant which is described in Report XVII, pp. 370–372.

The dump ores average 5.75 pounds of concentrates containing 60% WO_3 per ton. The mine ores vary somewhat but average about 18 pounds of 60% WO_3 concentrates per ton.

Water for milling operations has been developed in the flat, 7 miles northeast of the placer mill. First a well 400 feet deep was put down. This well is 3½ miles northeast of the placer diggings. It produced only 16,000 gallons daily. They then moved 3½ miles farther northeast and nearer to the dry lake; put down a 12-inch hole to a depth of 200 feet. Water is pumped from 115-foot depth by a Pomona turbine pump, driven by a 40-h.p. semi-diesel engine. Pumping from this well at the rate of 125,000 gallons daily does not lower the level of the water. The Pomona pump delivers to a tank at the No. 1 well, 3½ miles away. A Deane Triplex pump, motor driven, forces it the remaining 3½ miles.

It is now reported (July, 1930) that this property is temporarily idle.

Bibl: State Mineralogist's Reports XV, pp. 830–839; XVII, pp. 370–372; XX, pp. 96–97; Bull. 95, pp. 70–78 and 125–128.

Black Hawk Tungsten Mine, comprising 5 claims, is in the Atolia District, one mile west of the town of Atolia. These claims are the

Leonard and Halloran groups. Owner, Black Hawk Tungsten Mines Corporation; M. L. Conroy, president, 527 Front street, San Pedro, California. Idle.

Bibl: State Mineralogist's Report XVII, pp. 372–373.

Buckeye Tungsten Mine, consisting of 3 claims, is 1½ miles west by north from Atolia. It is north of the Black Hawk Mine. Elevation 3400 feet. Owner, Buckeye Tungsten Company; C. C. Ray, president; W. W. Keeling, secretary, Atolia, California. Idle.

Bibl: State Mineralogist's Report XVII, p. 373.

Carbonate Group of 6 claims is located in Cliff Canyon, on the north slope of the New York Mountains, 2 miles southeast of Brant, a station on the Union Pacific Railroad. Idle.

Bibl: State Mineralogist's Report XV, p. 841.

Federal Company's Group (formerly *Raynor Group*), composed of 10 claims and fractions, is in Secs. 19 and 20, T. 30 S., R. 41 E., M. D. M. Owner, J. C. Raynor, Atolia, California.

The claims are: Federal Reserve, Ready Cash, Federal Paymaster, Trade Dollar, Uncle Sam, Trade Dollar Extension, Wonder, Old Glory and Wedge Fraction, comprising 160 acres.

Development on the Federal claim consists of two shafts, 240 feet and 50 feet deep, respectively. On the 240-foot level there is 160 feet of drifts; on the 100-foot level, 100 feet crosscutting and 160 feet drifting. The vein is from 2 to 5 feet in width. There is a reported production of $30,000 from these two shafts.

On the Trade Dollar and Trade Dollar Extension there are several shallow shafts, maximum depth of 60 feet. Several of these are connected by stopes which have been worked up to within 15 feet of the surface.

One man employed on assessment work.

Gustave Group is south of Atolia on west side of railroad. Idle.

Bibl: State Mineralogist's Report XV, p. 837.

Irish Group of claims is in the Signal District, 10 miles south of Goffs. Owner, A. A. Irish, Grosse Building, Los Angeles.

Idle except for assessment work.

Bibl: State Mineralogist's Report XV, pp. 846–847.

Leonard and Halloran Groups (see Black Hawk Tungsten Mine).

Lombard and Main Group (formerly *California Vanadium Company*) is in the Signal District, about 8 miles north of Goffs. Idle.

Bibl: State Mineralogist's Report XV, pp. 845–846.

Mojave Annex Tungsten Mine is on the north slope of the New York Mountains, 2 miles southeast of Brant, a station on the Union Pacific Railroad. Idle.

Bibl: State Mineralogist's Report XVII, pp. 373–374.

Mojave Tungsten Mine, now consisting of 2 claims, is in the Clark Mountain District, about one mile south of the Colosseum gold mine. Owner, *Colosseum Gold Mines Corporation.*

Idle except for assessment work.

Bibl: State Mineralogist's Report XV, p. 839.

Nieto Placer Group is in the Atolia District just south of the Union Mine of the Atolia Mining Company. It consists of 3 placer claims, the Trinity, Triplex and Duplex, in Sec. 30, T. 30 S., R. 41 E., M. D. M., comprising 320 acres. Owner, John Nieto, Seaside Terrace, Santa Monica, California.

Many pits have been dug on this property and a large portion of the surface has been 'turned' by hand. This work was done by leasers who were looking for spuds. It is reported that good wages were made when the price of tungsten was $20 or more per unit.

The average depth to bedrock is 15 feet to 18 feet. While spuds may be found distributed throughout this depth, the real pay streak is reported to consist of from 6 to 24 inches of material on bedrock. This streak is not continuous, but lies in basin-like depressions.

Two shafts, each approximately 100 feet deep, have been sunk on ledges which cross the property. No ore of commercial value was encountered.

While this property is now idle, it is reported that an improvement in the tungsten market will result in the systematic development of this ground.

Osdick Group is in the Atolia District. It adjoins the Atolia Mining Company's property on the east. Owner, P. J. Osdick, Atolia, California.

This property produced some very high grade ore in 1916. Considerable development work was done at that time.

Bibl: State Mineralogist's Report XV, pp. 837–838.

Reynolds Custom Mill was erected at Goffs in 1916. It is now idle.

Bibl: State Mineralogist's Report XV, pp. 847–848.

Treasury Group is in the Atolia District adjoining the Atolia and Osdick groups on the south. Idle.

Bibl: State Mineralogist's Report XV, p. 839.

Tungsten King Group is on the south slope of the New York Mountains and about 9 miles east of Cima, a station on the Union Pacific Railroad. Elevation 6700 feet. Idle.

Bibl: State Mineralogist's Report XV, pp. 842–843.

United Tungsten Copper Mines are in the Morongo District, on the eastern slope of the San Bernardino Mountains, 50 miles southeast of Victorville. Elevation 6800 feet. Idle.

Bibl: State Mineralogist's Report XVII, p. 374.

VANADIUM

Occurrences of this metal have been found at Camp Signal, near Goffs, and two companies at one time did considerable development

work in the endeavor to open up orebodies of commercial quantities. Each had a small mill in operation in 1916, but no commercial output was made. Ore carrying the mineral, cuprodescloizite, was developed and reported to assay 4% V_2O_5. Vanadium occurs in the form of lead vanadate in the Gold Park District near Twenty-nine Palms, near the boundary line between Riverside and San Bernardino counties. Vanadium occurs at the Louisiana-California Mine as a coating along seams in the quartz vein in the form of cuprodescloizite. The occurrence is also noted 4 miles northeast of Kleinfelter, a station on the Santa Fe Railroad, on the Vanadium King Mine, owned by W. F. Chausse of Goffs, California. The ore is in the form of a vanadinite. Reported to carry 3% V_2O_5.

Bibl: State Mineralogist's Reports XV, pp. 849–852; XVII, p. 374.

NONMETALLIC MINERALS

The rapid growth of the city of Los Angeles in recent years has been the incentive for the establishment of industrial plants in the close vicinity of Los Angeles, which in turn has caused an increased demand for both industrial and structural materials. San Bernardino County has a great variety of commercial minerals, some of which are being used by industrial plants in Los Angeles, and a considerable tonnage of both industrial and structural materials are shipped to other manufacturing centers along the Pacific Coast.

The possibilities of the development of the 'industrial materials' are large and with increasing transportation and other facilities, together with the steadily growing demands, the future for this branch of the mineral industry in California is promising. The more important of these minerals thus far exploited as shown by output are: Barytes, clay, feldspar, fuller's earth, gems, lime, limestone, mineral water, miscellaneous stone, silica and talc. Cement is the most important single structural material in the mineral output of San Bernardino County. Three plants operating in the county during the year 1929 made a total of 3,576,005 barrels, valued at $4,603,301.

The most important development in recent years has been in the discovery and development of barite and bentonite deposits in the desert regions of the county. The increasing demand for barite for use in heavy-gravity, oil-well drilling mud, led to the shipment of a considerable tonnage of this material during the year 1929. The increased demand for colloidal clay of the bentonite class in place of true fuller's earth, because of its being utilized for clarifying, filtering and cleansing purposes, most of it in petroleum refining, has led to the development of a number of important deposits in the vicinity of Barstow, Daggett and Ludlow. There was a large increase in both amount and value in the output of this material during 1929.

ASBESTOS

Deposits of asbestos, of the amphibole variety, occur in the desert regions of the county, but so far no deposits of commercial value have been developed.

Cronese Asbestos Deposit. It comprises a group of 4 claims, situated 10 miles south of Baker and 4½ miles east of Soda, a station on the Tonopah and Tidewater Railroad. Owners, A. B. McAntire, Los Angeles, and Elmo Proctor, Yermo, California.

It is reported that both the chrysotile and amphibole varieties of asbestos occur in a belt of serpentine. Undeveloped.

Hicks Asbestos Deposit. This deposit is situated in the southern portion of T. 9 N., R. 4 W., S. B. M., 4 miles west of Hicks, a station on the Santa Fe Railroad.

The amphibole variety of asbestos occurs in a belt of serpentine which strikes northwest and southeast. The deposit is not of sufficient extent to be of commercial importance. Undeveloped.

Bibl: State Mineralogist's Reports IX, p. 236; XV, p. 852; Bull. 38, p. 263.

BARITE

Barium Queen Mine, consisting of 3 claims, is 5 miles northeast of Barstow, in T. 10 N., R. 1 W., S. B. M. It is on the south slope of a low range of hills, north of the Mohave River. Elevation 3000 feet. Owner, Ellis Mallery, 214 H. W. Hellman Building, Los Angeles.

A series of parallel veins occur in quartzite and schist; strike N. 30° W., dip 70° NE. The main vein, which can be traced on the surface for 4500 feet, is from 4 to 5 feet wide. The barite is white but is slightly iron-stained near the outcrop. The only gangue mineral is reported to be silica.

Development consists of a 250-foot tunnel and 6 shallow shafts, ranging from 20 to 60 feet deep. About 20 cars have been shipped. Used for conditioning oil-well mud. Idle.

Bibl: State Mineralogist's Report XVII, p. 334.

Big Medicine Barite Deposit is 6 miles northeast of Barstow and 1½ miles south of Lead Mountain. Owners, George Parks and Dr. Smith, Barstow, California. Under lease to J. B. Walker, Barstow, California.

On the northeast slope of a range of hills, a vein has been exposed by means of a small open cut; strike N. 45° W., dip 30° NE. It shows here a width of 4 to 6 feet and is filled with barite, which is iron-stained. Part of the barite is very coarsely crystalline but shades into the finer crystals in a schistose gangue. Some 1500 feet northeast of this work, considerable open cut work has been done on a vein of the same general character. The strike appears to be northeast, dipping flatly (about 20°) to the southeast. Here the vein as exposed in an open cut is about 8 feet wide. The barite is very finely crystalline and so banded as to give it the appearance of a gneissoid rock. The hanging wall is a finely-crystalline, dolomitic limestone, but the footwall has not been exposed. Some road building has been done with a power shovel and much of the vein is exposed in this manner. There is an open cut 50 feet long, 20 feet wide and 15 feet high at the face; of this height about 9 feet is overburden. Apparently, the cut has just reached the vein at its face. It is reported that this vein carries gold, silver and lead in the barite and quartz gangue.

Mr. Walker reports that he expects to build a concentrator to treat the ore, which is reported to be of chemical grade and is to be sold for this purpose.

Foshay Pass Deposit is located in Foshay Pass, 26 miles southeast of Kelso, a station on the Union Pacific Railroad. Idle.

Bibl: State Mineralogist's Report XVII, p. 334.

Hansen Deposit, consisting of 4 claims, is 3½ miles north of Ludlow. Owners, Harry B. Hansen, Ludlow, California. Under lease to H. A. Hukill, Ludlow, California.

Here a vein from 3 to 14 feet in width (average about 6 feet); strike N. 45° W., dip 45° NE., occurs in a basaltic formation. Vein filling is barite and iron oxide. In places, it is banded with brecciated wall rock, recemented by the barite. This main vein apparently forms a junction with a vein which on the surface is in the hanging wall and dips 45° to the west. The ore shoot formed along this junction. The shoot is 150 feet long and varies from 3 to 14 feet in width and has been stoped for a depth of 60 feet along its entire length.

Developed by a tunnel 60 feet below the outcrop. This tunnel was driven in a northwesterly direction a distance of 250 feet and stoped as noted above. At the north end of the present workings, the vein has been faulted to the east a distance of 8 feet. It here shows an open watercourse. The owner has shipped 58 cars and the present operators 2 cars from this deposit. Three men are employed in removing pillars from old stope.

Bibl: State Mineralogist's Report XXVI, pp. 54–55.

Lead Mountain Mine (Barite and lead. See under Silver-Lead.) It is situated in the Grapevine Mining District, in Sec. 36, T. 10 N., R. 1 W., S. B. M., 6 miles north of Barstow. Holdings comprise 640 acres. Owner, Lewis T. Buck, Los Angeles. Under lease to *Pacific Minerals Company*; K. A. Williams, president, Los Angeles.

The country rock is tuff, limestone and andesitic porphyry, the ore-bearing fissure strikes northwest and southeast and dips 40° NE. The width of the ore zone is about 100 feet and has been exposed for a distance of 1300 feet. The vein material is coarsely crystallized barytes, with quartz containing brown iron-oxides, galena, lead carbonate, manganese oxides and silver chlorides.

Development: West of the old workings and at a lower elevation, a crosscut tunnel has been driven north 150 feet, crosscutting the vein, with drifts northwest and southeast. The ore being mined from this level is trammed out to ore bins, from which it is loaded into trucks and hauled to the company's grinding and concentrating plant at Barstow. About 20 tons of crude ore is being mined per day. The ore is concentrated in Hancock jigs, producing a product having a high barite content.

Equipment at mine consists of 8-inch by 8-inch Ingersoll-Rand compressor. Twelve men are employed at mine and mill.

Bibl: State Mineralogist's Report XX, pp. 199–200.

Mansfield Deposit. It is situated six miles north of Barstow. Idle.

Bibl: State Mineralogist's Reports XV, p. 853; XVII, p. 334.

Massen Deposit. It is 2 miles southeast of Afton, a station on the Union Pacific Railroad.

Stringers of barite occur on contact of limestone and schist. Idle.

Bibl: State Mineralogist's Report XVII, p. 334.

Pierce Deposit. It is 12 miles east of Victorville. Barite occurs as filling in east-west fractures in the limestone. Idle.

Bibl: State Mineralogist's Report XVII, p. 334.

Pluth Deposit. It is situated 4 miles north of Daggett. Owner, Marcus Pluth, of Los Angeles. The vein is 4 feet wide, filled with white barite, free from iron. Idle.

Bibl: State Mineralogist's Report XVII, p. 334.

Waterman Mine Tailings. These tailings are located on the Waterman Ranch, 4 miles north of Barstow. Owner, Mrs. W. M. Waterman, Barstow, California. Under lease to Cooper Shapley, Bishop, California.

The estimated tonnage contained in this mill tailings dump is said to be 50,000 tons averaging 23% $BaSO_4$, with 3 ounces per ton in silver. A flotation plant having a capacity of 100 tons has been installed on the property.

The equipment consists of one 12-foot K and K Rougher cell, and one 9-foot K and K cleaner cell.

The product produced amounts to 20 tons of barite concentrates per 24-hour day. The concentrate produced has a specific gravity of 4.3 and carries 3 ounces in silver per ton. A recovery of 95% is reported. The concentrate is being shipped for oil-well mud.

Mr. Shapley also has an option on the old Waterloo Mining Company's tailings at Daggett.

Six men are employed.

Bibl: State Mineralogist's Report XXVI, p. 55.

BENTONITE (see FULLER'S EARTH)

CLAY

Deposits of high-grade clay occur at a number of localities in the county. A plastic kaolin of exceptional quality has been developed on a number of deposits in the Hart Mountains. Common clays are sufficiently abundant in the vicinity of San Bernardino for the manufacture of common brick to supply the local demand. The output of clay for 1930 amounted to 2013 tons, valued at $14,916, which was used in the manufacture of floor and roofing tile, pottery and refractories.

Bibl: Bull. 38, pp. 226–227, 253–254; Prel. Rept. 7, pp. 92–93; Bull. 99, pp. 193–199; State Mineralogist's Report XV, pp. 861–862.

Coors Kaolin Deposit. The property consists of 7½ claims, situated in Secs. 13 and 24, T. 14 N., R. 17 E., S. B. M., at Hart. Elevation 5500 feet. Owner, H. F. Coors, Inglewood, California.

The beds of clay have a thickness of 20 to 25 feet. The clay is a white-burning ball clay, possessing the properties of china clay and ball clay.

Developments consist of a trench 150 feet long, 8 feet deep and 15 feet wide, and two tunnels 70 and 100 feet in length. The clay is shipped to a plant located at Inglewood. Six men are employed.

Bibl: Bull. 99, pp. 194–195.

Gladding, McBean and Company's Clay Deposit. The deposit is situated 4 miles northeast of Bryman, a station on the Santa Fe Railroad, between Victorville and Barstow.

The clay bed has a thickness of 40 feet. The clay is a buff burning clay, which is mined and shipped to the company's plant in Los Angeles for use in the manufacture of face brick.

Development consists of an open cut 40 feet wide and 100 feet long. The production amounts to 150 tons per year.

Bibl: Bull. 99, p. 195.

Holliman and Murphy Clay Deposit. It comprises a group of 12 claims situated in Sec. 14, T. 12 N., R. 14 E., S. B. M., 7 miles southeast of Cima. Owners, R. H. Holliman and D. Murphy, Cima, California.

There are three distinct beds of white, semi-plastic clay, each of which is from 6 to 15 feet thick and can be traced along their strike for 2000 feet. Development consists of shafts and tunnels. Idle.

Bibl: Bull. 99, p. 195.

Le Feure Clay Deposit. It comprises 24 claims located in Sec. 26, T. 6 N., R. 14 E., S. B. M., 16 miles east of Amboy. Owner, C. B. Le Feure, Los Angeles.

The clay beds have a thickness of 14 feet. The clay is stated to have medicinal qualities. Developments consist of open cuts.

Chemical analysis by Arthur Mass, of Los Angeles:

SiO_2	30.9%
Al_2O_3	23.1%
CaO	21.1%
$CaCo_3$	37.7%
MgO	1.1%
MgCl	2.5%
Loss in ignition	22.3%
Free water	1.5%

Millet Clay Deposit. The deposit is situated in the west half of Sec. 31, T. 9 N., R. 3 W., S. B. M., 3 miles west of Hicks, a station on the Santa Fe Railroad. Owners, M. J. Millet and J. J. Kennedy, Daggett, California.

The clay is exposed on the surface about one-quarter of a mile south of a *ganister* deposit that is owned by the Atlas Fire Brick Company of Los Angeles. The clay bed is from 10 to 20 feet thick and can be traced along its east-west strike for a distance of several thousand feet. The clay is white to buff fire clay. Developments consist of open cuts. Idle.

Bibl: Bull. 99, pp. 195–196.

Standard Sanitary Company's Deposit. The deposit is situated one-half mile south of Hart. Owner, Standard Sanitary Company, Richmond, California.

The clay beds are from 60 to 70 feet in thickness. The clay is a white-burning ball clay.

Development consists of a tunnel 200 feet in length. From this tunnel the clay is mined in chambers, in sections 30 by 30 feet. The clay is hauled by motor truck to Ivanpah, a station on the Union Pacific Railroad, a distance of 15 miles. The production varies from

15 to 20 tons per day and the deposit is worked for three or four months of the year. Four men employed.

Bibl: Bull. 99, pp. 196–198.

Velvet White Filler Deposit. The deposit is situated 5 miles north of Oro Grande and 3½ miles east of Bryman, a station on the Santa Fe Railroad, in the Oro Grande Mountains. Owner, Velvet White Filler Company; A. B. Clark, president, Wayne, Nebraska; R. S. Clark, secretary, 510 West Sixth Street, Los Angeles.

Clay occurs in lenses. One lens has an average thickness of 17 feet, maximum of 25 feet. Strike of clay beds is N. 40° W. and occurs between walls of felsitic rock. The deposit consists of seams of white silica, talc and kaolin. The raw clay is stated to contain 25% aluminum.

The plant has a capacity of 8 tons per day. The process of treatment is as follows:

Raw clay to wash box, with agitators, to classifier; then to revolving screen, screened to pass 100-mesh. The product from screen to settling vats; then to driers; from driers to bar mill and after grinding in mill, the material goes to Bates packing machines.

It is utilized for paint filler, and by rubber manufacturers and for sizing paper. Three men are employed.

Bibl: State Mineralogist's Reports XV, pp. 861–862; XVII, p. 338.

Western Talc and Magnesite Company's Clay Deposit. It comprises 16 claims situated in Secs. 11 and 12, T. 9 N., R. 1 W., S. B. M., 5 miles east of Barstow. Owner, Western Talc and Magnesite Company, Los Angeles.

Beds of fire clay occur on these claims and its suitable for the manufacture of fire brick. Development consists of shafts and open cuts. Idle.

FLUORSPAR

Fluorspar, or calcium fluoride, CaF_2, is one of the most important nonmetallic minerals from an industrial standpoint. Its principal use is as a flux in the manufacture of steel; also used in aluminum smelting and in the manufacture of enamelware, glazed tile and brick, opalescent glass and certain chemicals.

There are several deposits of this important mineral in San Bernardino County but no commercial production has resulted.

Deposits.

Afton Ffuorspar Deposit (Massen). It is situated 3 miles southeast of Afton, a station on the Union Pacific Railroad, in the Cave Canyon Mining District. Elevation 2100 feet. Owners, W. H. Cornell and M. B. Randall, Los Angeles.

The fluorspur is a replacement of limestone on contact of andesite, felsite and sedimentary rocks. The deposit consists of a series of parallel veins, which trend east and west, with varying dips. The veins are from a few inches to 4 feet in width. The area containing these veins of fluorspar is well-defined, being about two miles in length

and about one mile in width. The color of the spar is green, white and purple. It is said that the grade mined in sample lots carried from 80 to 85% calcium fluoride, CaF_2, with a silica content of 5.40%.

Analysis is as follows:

Calcium Oxide	0.47%
Silica	5.40%
Aluminum oxide	2.26%
Iron oxide	0.14%
Calcium fluoride	90.78%
Loss in ignition	0.95%

Idle.

Bibl: State Mineralogist's Report XVII, p. 343.

Baxter Fluorspar Deposit. It comprises a group of 6 claims, situated south of Baxter, a station on the Union Pacific Railroad. Owner, J. Garrity, Baxter, California.

The color of the spar is green and white. It is reported that the fluorspar has a low silica and lime content.

McDermott Fluorspar Deposit. It comprises a group of 9 claims, situated 4 miles east of Nipton, a station on the Union Pacific Railroad. Owner, Mrs. R. H. McDermott, Los Angeles.

The fluorspar occurs in vein from 12 inches to 3 feet in width. Color: White, green and purple. The spar is stated to carry from 50 to 60% calcium fluoride, CaF_2.

Development consists of two shafts 50 and 60 feet deep, respectively, and a tunnel 20 feet in length. Idle.

Philadelphia Fluorspar Deposit. It is situated 25 miles south of Cima, a station on the Union Pacific Railroad, in the Providence range of mountains. Owners, C. Roberts and H. N. Benson, Los Angeles.

The fluorspar occurs in lenses of 6 inches to 2 feet in width. Fluorspar is said to analyze 74% CaF_2 and 3% SiO_2. The deposit is developed by a short tunnel. Idle.

FELDSPAR AND SILICA

Emsco Ganister Deposits. Owner, Emsco Refractories Company; E. M. Smith, president; S. B. Findley, vice president and general manager; local plant address, 5601 South Boyle avenue, Los Angeles.

This company opened a quarry which is approximately 2½ miles northeast of Wilde siding on the Santa Fe Railroad, about 20 miles northeast of Oro Grande.

It is a cone-shaped hill, about 150 feet high. The entire upper portion of this hill is composed of quartzite. It is probably 200 feet thick—the strike is N. 35° W. and it dips 45° NE.

Development consists of an open cut and a short tunnel, the portal of which was closed at the time of visit. A bin and two houses were erected on the property.

The above-described deposit was abandoned and the company transferred its operations to a similar deposit which is approximately nine miles east and slightly north of Victorville.

Here a quarry face has been developed which is 300 feet long by 20 feet high, in a wide belt of quartzite, the strike of which is east-west, dip 45° N.

This quarry is about one mile from the Southwestern Portland Cement Company's railroad, which connects with the Santa Fe at Victorville.

Material is shipped to Los Angeles for the manufacture of fire brick. There are three men employed loading with a gasoline-driven shovel.

Kennedy or Altas Fire Brick Company ganister deposit is about four miles northwest of Wilde siding on the Santa Fe Railroad. This deposit is similar to the Emsco and is probably a continuation of the same quartzite belt. Owner, Mr. Kennedy of Daggett, California. Idle.

Keystone and Lucky Jim Deposit. This property, consisting of ten claims, is located in Secs. 20 and 29, T. 2 N., R. 3 W., S. B. M., about one mile southwest of Arrowhead Lake, on the southwest slope of the San Bernardino Mountains. Elevation 5500 feet. Owners, C. Lillibridge and E. R. E. Nonhof of Corona, California. Under lease to W. M. Bledsor, on the property.

A series of segregations of feldspar and quartz occur in the granite; strikes vary from N. 10° W. to N. 55° W. All dip about 30° to the west.

Development consists of open cuts and short tunnels. Exposures in these workings show up to 4 feet of mixed quartz, feldspar and mica. In one place on the Lucky Jim No. 1 claim a shallow open cut shows a zone nearly 20 feet wide, with from 1 foot to 3 feet of spar on each side. This cut is too shallow to determine if the feldspar is clean or mixed with silica.

Reported to have shipped 30 tons of feldspar, 11 to 12 tons of silica and one ton of mica.

Lucky Betty Mining Company has 150 mining claims in the southeast foothills of the Clark Mountains, 16 miles southwest of Roach, Nevada. Elevation 4000 feet. Owner, Jos. Irwing, 1639 E. 102d street, Los Angeles; Clyde C. Downing, Reeves Aylmore and W. F. Baldwin.

A series of parallel pegmatitic dikes occur in the granite. Strike north-south, dip 60° W. These dikes are from 8 feet to 20 feet wide and are traceable across the property for a distance of about 1½ miles. Usually they are typical pegmatites, but frequently segregations of mica are found. Present development work consists of open cuts and short tunnels. It is proposed to develop the property by means of crosscut tunnels, the principal one of which has been started at a point some 200 feet west of the test plant.

Material is dumped into a 25-ton bin, thence by belt feeder to No. 1 Irving rock breaker, to bucket elevator, to ¼-inch vibrating screen; oversize passes over a steel lip beneath which is a slot through which a current of air is blown. This air current carries the mica over another lip, whence it falls into the No. 1 mica bin. The particles of silica, feldspar and mica which are not carried over by the air current return to the breaker. Screenings from ¼-inch screen go to 8-mesh vibrating screen, which has the same arrangement for air classification as the ¼-

Barber Bentonite Deposit, 18 miles north of Harvard, San Bernardino County.

inch screen. This mica product goes to No. 2 bin; also here the silica and spar mixture which is not blown over goes to a finished product bin. The minus 8-mesh goes to 16-mesh vibrating screen where the same operation is repeated. The products are No. 3 mica and No. 2 silica and spar. The minus 16-mesh goes to waste. Plant has a capacity of 100 tons per 24-hour day.

It is reported that the operation of this plant is satisfactory, its success being attributed to the breaker which separates the mica leaves without breaking them.

H. E. McKnight of Los Angeles has a deposit of *Cornish stone* in Sec. 16, T. 7 N., R. 2 E., S. B. M. It is at Willis Wells on the east slope of the Ord Mountains, 20 miles north of Box S Ranch. Holdings comprise 640 acres.

White Rock feldspar deposit consisting of two claims is 24 miles west of Needles and 6½ miles south of the highway. It is about 10 miles southeast of Goffs. Owner, P. Gerber, 7364 Sunset boulevard, Los Angeles.

It is reported that a 25-foot tunnel has been driven on a mixed quartz and feldspar segregation in the granite. The zone is 15 to 18 feet wide. Idle.

FULLER'S EARTH

Fuller's earth includes many kinds of unctuous clays. It is usually soft, friable, earthy, nonplastic, white and gray to dark green in color. Clays of the bentonite and hallosite group are being utilized by some of the oil refineries in California in lieu of true fuller's earth in the refining of petroleum products. The increasing demand for bentonite, a colloidal clay, has led to opening and development of a number of extensive deposits in San Bernardino County. There is a large increase in both amount and value of the 1929 output of this material over the previous year.

Bibl: State Mineralogist's Report XV, p. 863; Bull. 38, p. 275.

Deposits.

Balch Bentonite Deposit. It comprises a group of 6 claims, situated 10 miles northeast of Balch, a station on the Union Pacific Railroad, in Old Dad Mountains. Owners, F. H. Lietzon and Edward Saxton, of Los Angeles.

The clay beds have a thickness of 10 feet and an approximate width of 700 feet. Developed by a number of shallow open cuts.

Analysis:

Silica (SiO_2)	62.80%
Iron oxide (Fe_2O_3)	2.07%
Aluminum oxide (Al_2O_3)	18.45%
Calcium oxide (CaO)	0.98%
Magnesium oxide (MgO)	4.71%
Alkalies	3.09%
Total	98.72%

Barber Bentonite Deposit. It comprises 320 acres, situated 18 miles north of Harvard, a station on the Union Pacific Railroad and in the vicinity of Bitter Springs. Owner, A. M. Barber, Los Angeles.

The bed of bentonite that has been exposed by two open cuts has a thickness of over 100 feet and can be traced for over 3000 feet. The bentonite is white in color and of good quality. This deposit has possibilities of developing into a large producer. Four men employed.

California Talc Company's Bentonite Deposit. It comprises 320 acres, situated 5 miles south of Hector, a station on the Santa Fe Railroad, in the Lava Bed Mining District. Owner, California Talc Company; R. E. Scott, secretary, Los Angeles.

Bedded deposit of bentonite that is covered with an overburden of basalt and rhyolite. The bed has been exposed by open cuts for a length of 500 feet along its strike and about 150 feet in width. The bentonite is white in color and of good quality.

The company plans to ship a large tonnage to its plant which is located in Los Angeles. Six men employed.

Carewe-Morton Enterprise Company, 900 Clem Wilson Building, Los Angeles, has an option on a deposit of bentonite located 3 miles southwest of Hector, a station on the Santa Fe Railroad. The owner of this deposit is Emery Horner, of Hector, California. Holdings comprise 600 acres.

A number of shallow shafts and open cuts have been made on this deposit and the beds of bentonite exposed vary from 2 to 15 feet in thickness.

Analysis of bentonite made by Wilkinson and Burks, 300 San Fernando Building, Los Angeles is as follows:

SiO_2	54.48%
Fe_2O_3	0.84%
Al_2O_3	26.12%
CaO	1.01%
MgO	2.90%
SO_3	0.61%
Loss in ignition	13.70%

The bentonite is reported to be of good quality and there appears to be a possibility of developing a large tonnage of material on this deposit.

The Carewe-Morton Enterprise Company, 900 Clem Wilson Building, Los Angeles, also has a lease on a deposit of bentonite located approximately eight miles north of Toomey, a siding on the Union Pacific Railroad, five miles north of Yermo. The deposit is owned by R. H. Greer, Barstow, California.

One carload shipment has been made by this company for use in clarification of oil.

Horner Bentonite Deposit, consisting of 60 acres, is 20 miles east of Newberry, 25 miles west of Ludlow and 6 miles southeast of Hector, a station on The Atchison, Topeka and Santa Fe Railroad. Owner, *California Talc Company,* 837 West Jackson street, Los Angeles.

This deposit is in the Lava Beds District and is partially covered by the basaltic lava.

The bentonite occurs in layers which alternate with thin beds of limestone. The average thickness is probably about 4 feet. It outcrops intermittently over a distance of about 3 miles in the valley. Where there is no lava, the overburden consists of about 4 feet of ordinary aluminum clays. Colors are white to brown, the white being somewhat in excess.

The deposit has been opened by an open pit about 100 feet long by 25 feet wide and a maximum depth of 10 feet. Twelve cars have been shipped from this excavation. It is used in making a jel for oil-well mud.

Seven men are employed and their work is directed by V. M. Arciniego, superintendent.

Massen and Capek Bentonite Deposit. It comprises 60 acres, situated in T. 11 N., R. 5 E., S. B. M., 2½ miles north of Dunn, a station on the Union Pacific Railroad. Owner, J. H. Massen and J. W. Capek, Los Angeles.

A number of shallow open cuts expose a bed of bentonite which is said to be of good quality and there appears to be a possibility of developing a large tonnage. The bentonite is associated with red clay and iron oxide. Idle.

Potter Bentonite Deposit. It comprises 480 acres, situated in T. 9 N., R. 1 W., S. B. M., 5 miles southeast of Barstow. Owner, Elmer Potter, Los Angeles.

The bed of bentonite is from 15 to 20 feet thick and has been exposed for a distance of 500 feet along its strike. The bontonite is white to gray in color and reported to be of good quality. Idle.

GEMS

The gem stones that have been found in the desert sections of San Bernardino County are as follows: Agate, garnets, quartz crystals, lapis lazuli, sapphires and turquoise.

There has been no recorded production of gem materials from the county in recent years. The turquoise deposits which are located in the Solo Mining District, 30 miles northwest of Cima, a station on the Union Pacific Railroad, were last worked in 1903.

Bibl: Bull. 37, pp. 76–167; State Mineralogist's Report XV, pp. 863–868; U. S. Geol. Survey Mineral Resources 1898, pp. 582–584; Mineral Resources 1911, Part II, pp. 1059–1060.

GARNET

Allison Deposit is 6 miles northeast of Amboy in the Bristol Mountains. It is on the ground known as the Snowcap Limestone Deposit. Owner, Robert Allison, Nadeau Hotel, Los Angeles.

The garnet, which is finely crystalline, occurs in the limestone, or more probably at its contact with an igneous dike, which, however, is not exposed on the surface. The strike is east-west and it is apparently some 20 feet wide. It may be traced over a spur for a distance of several hundred feet. The individual crystals are comparatively small; the color varies from green, through red to almost black. It is suitable for use as an abrasive.

Lena Louise Garnet Group of 5 claims is in the Marble Mountains, 5 miles north of Cadiz, a station on the Santa Fe Railroad. Owner, J. A. Chambless, Amboy, California. It is under lease to *California Reserve Co.,* Fourth and Spring streets, Los Angeles, California.

It is reported that there are two principal contact zones into which the garnet minerals are segregated. Limestone and granite form the contacts. The strike is northwest-southeast. The zones are said to be approximately 100 feet wide and the garnet 'veins' are accompanied on each side by zones filled with iron and epidote.

The lessee is building a road to the deposit preparatory to shipping the material for use as an abrasive.

GYPSUM

Deposits of gypsum occur in the desert region of San Bernardino County, but there has been no production in recent years. Gypsum occurs loosely cemented with sand in coarse crystals in Bristol Lake near Amboy. A similar deposit occurs at Danby Dry Lake. Gypsum also occurs in thin-bedded deposits associated with the beds of rock salt in the Avawatz Mountains and to a lesser extent in the borax beds of the Calico District.

Bibl: State Mineralogist's Reports XV, pp. 868–870; XVII, pp. 351–352; XVIII, p. 232; Bull. 38, 67, 91; U. S. Geol. Survey Bull. 223, 413, 430, 697; U. S. Bur. of Standards, Circular No. 281.

Couchman Gypsum Deposit. It comprises 160 acres, situated at Coyote Holes, 12 miles NE. of Valjean, a station on Tonapah and Tidewater Railroad. Owner J. Couchman, Los Angeles, California. Analysis show 94% gypsum. Reported that the gypsum beds are extensive. Undeveloped.

LIMESTONE (CEMENT, MARBLE AND DOLOMITE)

Arlington Mining Corporation has deposits of limestone in Blackhawk Canyon, which is on the northeast slope of the San Bernardino Mountains, largely in T. 3 N., R. 1 E., S. B. M., some 25 miles southeast of Victorville. Elevations range from 4200 to 6700 feet. Owner, Arlington Mining Corporation; Algernon Del Mar, president; Roy K. Voorheis, secretary. Offices: 740 South Broadway, Los Angeles.

In a bulletin written by A. O. Woodford and T. F. Harris, issued by the Department of Geological Sciences of the University of California, Vol. 17, No. 8, the geology of this region is discussed in detail. Sections shown in this paper indicate thicknesses of limestone up to some 700 feet.

Quoting from this publication, under description of the Furnace Limestone: "It is crystalline, the mineral individuals averaging about one millimeter in diameter. Sometimes banding is pronounced owing to variations in color or in grain (even up to centimeter size) and usually caused by vague changes in shade from light to dark gray. Some of the limestone is dazzingly white, and much of lower portion as here exposed is stained red.

"Some parts of the limestone are composed of practically pure calcite, containing little or no magnesia. Sometimes dolomite grains are common * * *."

Analyses given indicate an average composition of approximately 98% calcium carbonate, and about 1.1% magnesium carbonate.

There are numerous deposits of limestone and marble in San Bernardino County, which because they are idle are not here mentioned. See Bulletin No. 38, pp. 102–106 for additional descriptions.

Baker Limestone Deposit. It comprises 160 acres in T. 4 N., R. 8 E., S. B. M., one mile west of Baker, a station on the Tonopah and Tidewater Railroad. Owner, J. W. Neblett, Riverside, California.

The deposit forms a rounded hill that rises above Soda Lake Valley to a height of 400 feet and is 2 miles in length, along its north-south axis. The limestone is crystalline, blue to gray in color and is approximately 98 per cent calcium carbonate.

Baxter and Ballardie Quarries. This property is in Sec. 12, T. 11 N., R. 6 E., S. B. M. It is near Baxter, a station on the Union Pacific Railroad. (See also Pacific Marble Quarries Company.) Idle for the past two years. For description see

Bibl: State Mineralogist's Report XV, pp. 872–876.

Big Pine Deposit, consisting of three placer claims, 480 acres, is in Secs. 1 and 6, T. 3 N., R. 8 W., and Sec. 36, T. 4 N., R. 8 W., S. B. M. It is on the line between Los Angeles and San Bernardino counties, just above and east of Los Angeles County Recreation Camp on the north slope of the San Bernardino Mountains, just north of Swartout Canyon. Elevation 7500 feet. Owners, Big Pine Mining Company; R. E. Shonerd, president, 10909 Kenwood Street, Inglewood, California; B. D. Elder, secretary, 3106 Berkeley Avenue, Los Angeles.

On this property a belt of limestone from 200 feet to probably 400 feet thick is traceable for more than one mile. The exposures are best seen in the canyons, the outcrop on the tops of the ridges being largely covered by detritus. The strike is east-west, with 45° dip to the south. It is a white crystalline limestone, analyses of which show it to contain from 85% to 95% calcium carbonate.

Only development consists of shallow opencuts scattered over the property.

Cajon Limestone Deposit. It comprises 420 acres situated in Lone Pine Canyon, 4 miles west of Cajon, a station on the Santa Fe Railroad. Elevation 3000 to 5000 feet. Owner, Cajon Lime Products Company; Lorin O. Forman, president, Forman and Clark Building, Los Angeles.

The belt of crystalline limestone strikes northwest and southeast and occurs in Pre-Cambrian gneiss and schist. This belt of limestone is about one-half mile in width and the outcrop can be traced to Swartout Canyon.

Three quarries have been opened up on the north side of road from Cajon to Swartout Canyon. The plant consists of rotary kiln, capacity 125 tons per day and is located on the west side of Cajon Canyon. Plant was built in 1924 and operated for several years. Idle.

California Portland Cement Company's plant and quarry is in Secs. 19 and 30, T. 1 S., R. 4 W., S. B. M., about one mile west of Colton. Owner, California Portland Cement Company, Pacific Mutual Bldg., Los Angeles, California; Dan Murphy, president; E. E. Duque, vice president and general manager.

The plant is at the south end of Slover Mountain. This mountain is composed of crystalline limestone, all of which is suitable for the manufacture of cement. It is approximately one mile long, a half mile wide and 500 feet high. The present quarry face is 3500 feet long and has a maximum height of 400 feet.

The material is loaded into cars by steam shovels and hauled to the crushing department by electric storage-battery locomotives.

Cars are dumped by electrical power into 84 by 66 inch jaw crusher, thence to No. 9 gyratory, elevated to No. 18 gyratory; elevator to trommels. The minus $\frac{3}{4}$-inch goes to storage bins, oversize by conveyor to hammer mill, which crushes to $\frac{3}{4}$-inch. This crushed material contains the approximate proportions of clay and shale.

From the storage bins it goes through driers to twelve 250-ton proportioning bins, where it is held until analyses of samples show that the proper mixture has been attained. From these bins it goes to the raw-grinding division, consising of compartment ball mills and Fuller Lehigh mills, equipped with air separators, grinding to 88% minus 200 mesh, thence to storage in silos. From the silos material is delivered to kilns by Fuller-Kinyon pumps. From the kilns to clinker storage; reclaimed by traveling crane, and sent to finished grinding, consisting of tube mills, thence to finished storage.

The packing plant consists of sack cleaning and repairing departments and Bates packers.

Plant is reported to have a capacity of 12,000 barrels daily.

Power is obtained from the Southern Sierras Power Company.

Bibl: State Mineralogist's Reports XV, pp. 857–858; XVII, pp. 335–336.

Chalmers Dolomite Deposit. This property consists of 640 acres, located $2\frac{1}{2}$ miles southwest of Amboy, a station on The Atchison, Topeka and Santa Fe Railroad. Owner, J. K. Chalmers, 632 H. W. Hellman Building, Los Angeles, California.

The deposit forms low hills, which rise from 50 to 100 feet above the floor of the valley. Analyses of the dolomite show that it is composed of 50% $MgCO_3$ and 50% $CaCO_3$.

The freight rate to Los Angeles is $2 per ton. Idle, except for assessment work.

Cima Limestone Deposit is in Secs. 12, 13 and 24, T. 15 N., R. 13 E., and Sec. 7, T. 15 N., R. 14 E., S. B. M., about 10 miles northerly from Cima, a station on the Union Pacific Railroad. It embraces 10 placer claims—1380 acres. Elevation ranges from 4900 to 5900 feet. Owners, H. O. Hinshaw, Riverside County Chamber of Commerce, and R. F. Slaughter, 579 Magnolia avenue, Riverside, California.

The deposit constitutes the main portion of a westerly spur of the Ivanpah Mountains. The high points of this spur rise from 400 to 700 feet above the floor of the valley, while the intervening saddles are from 100 to 200 feet lower.

The individual limestone strata vary in thickness from 10 to 300 feet. The texture varies from very fine grained to coarsely crystalline. The colors are white, light gray and nearly black. Near the summits of the peaks there are some thin strata of brown, siliceous limestone. The dips vary from 20° to 80° N. On the east, the base of the limestone is in contact with a granitic mass, which apparently caused the uplifting.

Analyses of four samples taken from the deposit are reported to average 97.5% calcium carbonate and 0.40% magnesium oxide.

Idle, except for assessment work.

Golden State Portland Cement Company's plant at Oro Grande has been taken over by the *Riverside Portland Cement Company,* 621 South Hope street, Los Angeles, California; John Treanor, president.

This plant has been idle for the past two years.

Since the last report some changes have been made in this plant, including the construction of silos for cement storage.

For description see

Bibl: State Mineralogist's Reports XV, pp. 858–859; XVII, p. 336.

Hinkley Dolomite Deposit, comprising 160 acres, is in Secs. 11 and 12, T. 9 N., R. 4 W., S. B. M., four miles southwest of Hinkley, a station on The Atchison, Topeka and Santa Fe Railroad. Owner, R. J. Tones, 906 Colton avenue, Colton, California.

It has been estimated that this deposit contains 25,000,000 tons of dolomite, the analysis of which shows it to be composed of 30% calcium carbonate and 40% magnesium carbonate.

Jack Frost Deposit, consisting of 160 acres, is in the Bristol Mountains 6½ miles northeast of Amboy, a station on The Atchison, Topeka and Santa Fe Railroad. Elevation ranges from 1400 to 1800 feet. Owners, D. N. Smith and associates, Los Angeles, California.

This deposit of crystalline limestone is approximately 3000 feet long, 1200 feet wide and 400 feet thick. The strike is northwest-southeast and the dip 30° to 40° NE.

It has been intruded by a series of dioritic and andesitic dikes, strike N. 30° W., dip 60° to 70° NE.; also deposits of epidote occur at the contact of the limestone with granite near the northeast corner of the deposit.

Idle, except for assessment work.

Lawton Deposits. John P. Lawton of Sierra Madre, California, has deposits of limestone and dolomite in sections north of Keenbrook, a station on the Santa Fe Railroad. Holdings comprise 800 acres.

Lucky Strike Deposit, consisting of 160 acres, is in T. 2 N., R. 4 W., S. B. M., on the southwest slope of the San Bernardino Mountains, about 12 miles north of the city of San Bernardino.

The Arrowhead Lake highway passes through this deposit. Elevation approximately 4500 feet. Owners, C. Lillibridge and E. R. E. Nonhoff, Corona, California, under lease to Harry D. Stanley, 916 South Lake street, Los Angeles, California.

The new highway to Arrowhead and Big Bear Lakes is cut through the limestone on this property and is the only development work which

was seen. It is white to gray in color and apparently is high grade crystalline limestone. The deposit has an apparent thickness of from 150 feet to 200 feet and has been exposed in the highway cut for a distance of about 1000 feet. At the west end of the exposure the dip is about 20° to the east, but a very distinct north-south fault crosses it near the upper or east end. Beyond this fault, which is indicated by a thoroughly crushed zone more than 100 feet in width, the dip is approximately 15° to the west. The mountain side is very steep and quarrying without interfering with the highway would be difficult.

A. B. McAntire, 7721 South Main street, Los Angeles, and Elmo Proctor, Yermo, California, own a deposit of marble in the Mojave Sink country. It is 4½ miles east of Soda, a station on the Tonopah and Tidewater Railroad, and 10 miles south of Baker. Holdings comprise 4 claims.

The deposit forms a hill which rises approximately 400 feet above the floor of the valley.

It is reported that the marble, which occurs in beautifully variegated colors, may be quarried in blocks of sufficient size to be used in the building trades.

To date only assessment work is being done.

Mojave Marl Company has a mill at Wilde Siding on the Santa Fe Railroad, about 16 miles east of Oro Grande. Their deposit is about 2 miles west of the mill and one mile north of the railroad. Owner, Mojave Marl Company, 374 Court street, San Bernardino, California; L. Johnson, president, 472 Fourteenth street, San Bernardino. The plant consists of Williams mill, to 14-inch conveyor belt to bins, thence to 20-inch belt conveyor to elevator and railroad cars. Capacity of plant is 15 tons per hour. Now shipping 35 to 50 tons per day into the orange belt for fertilizer.

O'Connell Deposit, consisting of 6 claims, each 160 acres, is 3 miles southeast of Ivanpah, a station on the Union Pacific Railroad. Owner, Tom O'Connell, San Bernardino, California.

This belt of limestone is here 300 feet wide. Its strike is northeast-southwest and it dips to the north. It is reported to average 99% calcium carbonate.

Idle, except for assessment work.

Pacific Marble Quarries Company (see also Baxter and Ballardie Quarries), Citizens' National Bank Building, Los Angeles, California. R. B. Knox, president; J. M. Finlayson, secretary.

This company operated the Baxter and Ballardie Quarries, 1923–1926.

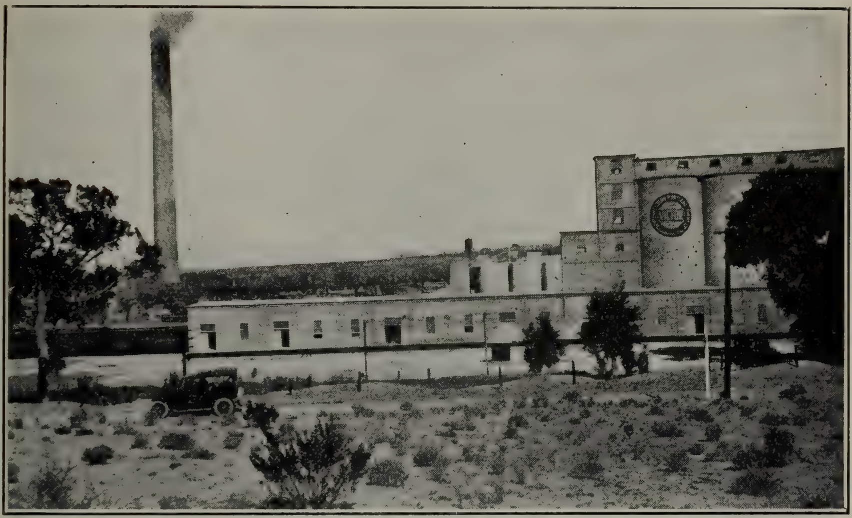
Bibl: State Mineralogist's Report XV, pp. 872–876.

Parker Marl Deposit. W. Floyd Parker, 1320 Angeleno street, Los Angeles, California, has a marl deposit, consisting of 8 claims, 1780 acres. It is 7 miles east of Barstow. Idle.

Schiedel Deposit is in Secs. 5, 11 and 14, T. 12 and 13 N., R. 14 and 15 E., S. B. M., about 5 miles from Elora, a station on the Southern Pacific Railroad. Owners, John Schiedel, 639 St. Paul avenue, Los Angeles, and associates.

It is estimated that there is 500,000 tons of pure crystalline limestone on these two claims.

Silver Dome Deposit is in Sec. 32, T. 12 N., R. 42 E., M. D. M., 20 miles southeast of Randsburg. It consists of 160 acres, held in conjunction with the lode claims, comprising the gold mine of the same



Southwestern Portland Cement Company's plant, Victorville, California.

Silver Lake Limestone Deposit, San Bernardino County.

name. It is easily accessible by level roads from Fremont Siding on the Kramer-Johannesburg branch of the Santa Fe Railroad. Owner, Silver Dome Mining Company, Phoenix, Arizona; Capt. A. Rolling, president; Fred Knappen, secretary.

The deposit, which forms a long, low, gently-sloping hill, is estimated to contain 15,000,000 tons of clear white crystalline limestone, which is composed of 98% calcium carbonate.

Development consists of small open cuts and short tunnels.

Silver Lake Limestone Deposit. This deposit, comprising 120 acres, is 3 miles west of Silver Lake, a station on the Tonopah and Tidewater Railroad. Owner, G. M. Shelley, 847 N. Orange Grove avenue, Los Angeles.

The deposit has no overburden and it consists of crystalline white limestone, an analysis of which shows 99.8% calcium carbonate.

Snowcap Limestone Deposit, consisting of 160 acres, is about 6 miles northeast of Amboy, a station on the Santa Fe Railroad. It is on the southeast slope of the Bristol Mountains. Owner, Robert Allison, Nadeau Hotel, Los Angeles, California.

This deposit is easily accessible from Amboy over a good road, no grade.

The deposit is approximately 700 feet thick by 1500 feet long. The main portion of it forms a cone-shaped peak some 350 feet high. It is reported that the entire deposit consists of a white, crystalline limestone which is approximately 98% calcium carbonate.

Snow White Marble Company's Deposit is in the New York Mountains, 4 miles southwest of the town of Barnwell. It adjoins the Sagamore Mine.

The property, consisting of 6 claims, 120 acres, is owned by J. L. Parsons, 1987 Linda Vista, Pasadena, and J. I. Taft, 1968 West avenue, Linda Vista, California, and associates.

Southwestern Portland Cement Company, H. W. Hellman Building, Los Angeles, California. F. H. Powell, president; M. A. Koffman, secretary.

This company supplies its cement plant at Victorville with limestone from its quarries. which are some seven miles distant in a northeasterly direction.

Five quarries have been developed in a limestone belt, the strike of which is east-west dip 45° N. To the south is a wide belt of quartzite, through about 200 feet of shale, against which is a monzonite of undetermined extent. The actual thickness of the limestone is nowhere, as yet, exposed, although some quarry faces are nearly 200 feet high. The limestone is crystalline, the color being both blue and white.

The five quarries are in two hills, separated by a shallow canyon. Quarries Nos. 1, 3 and 5, in the most northerly hill, have an aggregate quarry face length of 3200 feet by an average height of approximately 75 feet. Quarry No. 4, to the south, has an 1800-foot face, which is in one place 180 feet high.

The rock is loaded into 30-ton, standard gauge side-dump railroad cars by one Bucyrus electric shovel, 3-cubic-yard dipper, caterpillar type, and one Bucyrus steam shovel, 1¾-cubic-yard dipper, railroad type; also one Marion electric shovel, 2½-cubic-yard dipper, caterpillar type. The company owns and operates the seven miles of railroad over which these cars are pulled to their plant.

Other equipment at the quarry consists of 2 steel and 1 wooden Armstrong drill rigs.

The plant has been described in our former reports, since which time, however, its capacity has been increased to 6000 barrels daily. Two kilns have been added; one 200 feet long by 9 feet in diameter; the other is 200 feet long by 9 feet in diameter at the feed end and 13 feet 6 inches in diameter at the burning end.

The silo capacity has been increased to 140,000 barrels.

A total of 270 men are employed.

Bibl: State Mineralogist's Reports XV, pp. 859–860; XVII, p. 337.

Standard Limestone Deposit is 2 miles northeast of Ivanpah, a station on the Union Pacific Railroad. It comprises six 160-acre claims. Elevation 4000 feet. Owner, *Standard Lime Chemical Company,* L. Brandenberg, president, Los Angeles, California.

Limestone Quarry. Southwestern Portland Cement Company, Victorville, California.

This deposit consists of a belt of white and gray crystalline limestone which is reported to consist of 99% calcium carbonate. It is approximately one mile wide by two miles long, strike N. 30° W.

Development consists of a 30-foot shaft and exposures in cuts of the old Ivanpah branch railroad.

Three Colored Marble Quarry is in the unsurveyed portion of T. 7 N., R. 2 W., S. B. M., 22 miles south of Barstow.

For description of this deposit see

Bibl: State Mineralogist's Report XV, pp. 881–883.

Verde Antique Marble Quarry, formerly known as the *Gem Quarry* or the *Kimble Mine,* is in Sec 28, T. 7 N., R. 2 W., S. B. M., about 2 miles southwest of the Three Colored Marble Quarry.

Bibl: State Mineralogist's Report XV, p. 883; Bulletin 38, pp. 147–148.

MAGNESITE

Afton Magnesite Deposit. It comprises 3 claims, situated 1½ miles east of Afton, a station on the Union Pacific Railroad. The deposit is located on a steep hillside on the east side of Cave Canyon.

The deposit of magnesite is 10 to 20 feet thick, strikes east and west and dips north. The magnesite underlies a soft, red-colored, decomposed conglomerate. The footwall of the magnesite vein is made up of sandstone and dark, bluish, gray shales. Its color varies from pinkish to dead white. Occasional seams of silica are imbedded in the magnesite.

Analysis of magnesite (Smith-Emery and Company).

Silica (SiO_2)	10.10%
Aluminum (Al_2O_3)	1.73%
Iron (Fe_2O_3)	1.41%
Lime (CaO)	3.10%
Magnesium oxide (MgO)	38.19%
Carbon dioxide (CO_2)	40.65%

Bibl: State Mineralogist's Report XVII, pp. 353–354.

New Trail Magnesite Deposit. This deposit occurs on the claims of the New Trail Mining Company, situated 10 miles northwest of Cima, a station on the Union Pacific Railroad, on the east slope of the Ivanpah range of mountains. Owner, New Trail Mining Company; J. F. Kent, president, Riverside, California.

The magnesite occurs along the bedding planes of dolomitic limestone. The vein of magnesite is 2 to 4 feet thick, strike NE. and SW., dip 45° SW. It has been developed by a number of shafts to a depth of 80 feet, for a distance of 500 feet along its strike. The magnesite is dead white in color but probably carries high lime content. Idle.

MICA

Practically all marketable mica is the muscovite or phlogopite varieties. There are three main commercial classes: Sheet mica, including punch, splittings and scrap.

Deposits of muscovite, associated with feldspar and silica, occur on the east slope of Clark Mountain, at Little Betty Mine. For a description of the deposit, the reader is referred to the *Little Betty Mine,* described under feldspar and silica.

There is also a deposit of mica situated on the east slope of the Ivanpah range of mountains. This deposit occurs on the southern end of the claims owned by the *New Trail Mining Company* of Riverside, California. The mica occurs in quartz-diorite along north and south and northeast and southwest fractures. A number of shallow shafts have been sunk on the deposit, exposing 6 to 8 feet of greenish to black-colored mica. It occurs in plates up to 2 inches but breaks up readily to finer material on being exposed to the air. The deposit has potential possibilities and a large tonnage can be developed.

MINERAL WATER

There are a great many mineral springs in San Bernardino County and these are described in detail in U. S. Geol. Survey Water Supply Paper 338, by Gerald A. Waring.

The principal commercial output of mineral water in the county is from Arrowhead Hot Springs, owned by the Arrowhead Hot Springs Company, offices and bottling plant located at Washington street and Compton avenue, Los Angeles.

Bibl: State Mineralogist's Report XV, pp. 883–890; U. S. Geol. Survey Water Supply Paper 338, pp. 32–36.

PUMICITE

Hill Bros. Chemical Company, 2159 Bay Street, Los Angeles, has a lease and bond on a pumicite deposit owned by C. H. Greer, Barstow, California. It comprises two placer claims known as Blue Mud No. 1 and No. 2, located in Sec. 19, T. 11 N., R. 2 W. and Sec. 24, T. 11 N., R. 3 W., 12 miles northwest of Barstow. The material is a clay with a high silica content. The following is an analysis of the clay:

SiO_2	70.00%
Al_2O_3	13.76%
Fe_2O_3	2.00%
CaO	4.40%
MgO	0.94%
P_2O_5	0.02%
Titanium oxide	0.10%
Na_2O	1.92%
K_2O	1.93%
Ignition loss	4.00%

This is a bedded deposit 50 to 100 feet in thickness and extends over practically both claims. Twenty-five cars of the material has been shipped from this deposit by the Hill Bros. Chemical Company. It is used as an admixture and comixture in cement.

SALINES

Under this heading are included borax, nitrates, common salt, soda, potash and other alkaline salts. The main resources of the salines are the dry lake beds of the desert region of San Bernardino County.

The principal commercial production of the salines is made up of borax, salt, soda, potash, magnesium chloride, magnesium sulphate and calcium chloride.

Borax, soda and potash are recovered from the brines of Searles Lake, which is located in the northwest corner of the county. San Bernardino County is the chief source of potash in the United States and the source of supply is in the saline brines of Searles Lake.

Nitrates of sodium, potassium and calcium have been found in various places in the desert regions of the county, but no deposit of commercial value has been developed as yet.

The principal deposits of salt occur in the dry lake beds of Bristol Lake, near Amboy, Danby Dry Lake and Cadiz Dry Lake, near Milligan. The principal production of sodium salts in the county is recovered from the brines of Searles Lake, in the form of soda ash, bicarbonate of soda, and trona (sesqui-carbonate), a double salt of Na_2CO_3 and $NaHCO_3$. The production of calcium chloride came from two plants, being obtained as a by-product in the refining of salt from

the deposits of Bristol Lake. The first commercial production reported was in 1921. The production from 1921 to 1929 amounted to 47,070 tons valued at $887,184.

BORAX

The first production of borax in the county was from the dry lake (playa) deposits, and began in 1873; but it was not until 1887 that the borax industry was revolutionized by the discovery of the colemanite beds in the Calico Mountains.

The production of borax from this district amounts to more than $10,000,000. About 1892 extensive deposits of colemanite were found in Inyo county, which caused the suspension of operations in the Calico District, and only a small amount of selected ore has been shipped from these deposits in recent years. At present writing the only production of borax is crystallized borax prepared by evaporation of the brines of Searles Lake. The present production amounts to about one-third of the borax produced in the United States.

MAGNESIUM SALTS

American Magnesium Company, T. W. Wright, president, Los Angeles, California. This company owns 1000 acres of placer ground, carrying soluble magnesium sulphates, located in T. 25 S., R. 46 E., S. B. M., 30 miles east of Magnesium, a siding on the Trona Railroad. The plant is located on the southwest shore of Searles Lake, 6 miles south of Trona. A monorail crosses Searles Lake from the plant to the deposit, a distance of 30 miles. Product produced was magnesium carbonate and magnesium sulphate (Epsom salts). After short period of operation the company closed down. Idle.

NITER

The existence of niter in the low, rolling hills along the Amargosa River has been known since the early eighties. The niter beds are situated in the northern part of San Bernardino County, extending across the boundary line into the southeastern part of Inyo County. The formation of the niter-bearing hills occurred in the early Tertiary period, and are the result of sedimentary marine deposits slowly accumulating in thin layers. These beds have been worn by erosive agents into soft rounded hills and knobs. The hills are covered with a crust; this crust, varying from a few inches to over a foot in thickness, is termed 'Caliche.' The 'Caliche' contains niter, and also the clay beds underlying the 'Caliche' contain niter. It is reported that the 'Caliche' contains from 5% to 10% niter.

Bibl: State Mineralogist's Report No. XV, pp. 890–891; Bulletin 24, pp. 174–178.

POTASH

American Potash and Chemical Company. H. S. Enslow, president; F. C. Baker, vice president; F. C. Baker, secretary and treasurer; offices, New York City. Plant executives: Frederick Neweg, general manager; W. E. Burke, assistant manager; O. M. Simpson, assistant manager; offices, Trona, California.

The plant is situated on the northwest shore of Searles Lake. Elevation 1600 feet. Holdings comprise about 3320 acres. Searles Lake is a broad circular valley or depression from 8 to 10 miles from east to west and from 20 to 25 miles from north to south. This basin lies between the Argus range on the west and the Slate range on the east.

The saline deposits of Searles Lake comprise several distinct areas. First: The central area of firm crusted salt, consisting of the main salt deposit, or crystal area, which is 13 square miles in extent. Second: The playa zone, including the central salt area and a broad surrounding margin of salt incrusted mud and sand, composed of mud and mixed alluvial material. The area of the playa zone is about 60 square miles. The average depth of the salt in the main part of the deposit is 70 feet.

The whole body of salt in this shallow basin of crystallized salts and brine is composed of five definite materials.

1. Halite—($NaCl$).
2. Trona—($Na_2CO_3.NaHCO_3.2H_2O$).
3. Hanksite—($9Na_2SO_4.2Na_2CO_3KCl$).
4. Borax—($Na_2B_4O_7.10H_2O$).
5. Glaserite—($3K_2SO_4.Na_2SO_4$).
6. Burkeite—($2Na_2SO_4.Na_2CO_3$).

Composition of Searles Lake Brines:

Sodium Chloride ($NaCl$)	16.36%
Sodium Carbonate (Na_2CO_3)	4.86%
Sodium Sulphate (Na_2SO_4)	6.85%
Potassium Chloride (KCl)	4.74%
Sodium Borate ($Na_2B_4O_7$)	1.50%
Total solids	34.38%

The base of the deposit consists primarily of sodium carbonate and sodium bicarbonate. There is an increase in the upper parts of the deposit of sodium sulphate and a concentration of sodium chloride at the top of deposit.

Plant. Commercial production of potash by the plant of the American Potash and Chemical Company, started in 1916, and was under continuous operation from 1916 to 1921, when operations were suspended until the early part of 1922, for experimental purposes, and also to increase the capacity of the plant. Since March, 1922, the plant has been operating continuously. The production of borax was started in 1924, which was increased to 125 tons in 1927. The production for the year 1928 amounted to 138,291 tons of potash and borax salts, the net profit for the year being $1,556,541. The net income reported for the year 1929 was $1,348,428, with net sales from potash and borax salts amounting to $4,279,600. The present production of the plant amounts to 140 tons of borax, having a grade of 99.95% borax, and 256 tons of potash carrying 95% KCl, per day.

Power Plant. It comprises a battery of 14 Babcock-Wilcox boilers, each rating 500 h.p., the total horsepower generated being from 7000 to 10,000, with three chimney flues, 150 feet in height by 9 feet in

diameter. The power plant uses 55,000 gallons of crude fuel-oil per day. The cooling towers adjoining the plant have a capacity of 20,000 gallons of water per minute. The steam from the boiler plant goes directly to two General Electric Company steam-turbine generators which furnish power for the operating plant—also light for plant and buildings on the company's property. The exhaust steam from the turbines goes to triple-effect evaporators. The compressor plant consists of six compressors, and three refrigerating engines for use in the process of refrigeration and crystallization of borax. The brine treated carries from 4.75% to 5% KCl and has a temperature of 72° Fahrenheit.

Method of Treatment of Brines. Ten wells have been sunk in the center of Crystal Lake area, and brine is pumped by centrifugal pumps through an insulated pipe line 10 inches in diameter, a distance of about 3 miles to large steel storage tanks having a capacity of 2,000,000 gallons of brine. The brine from storage tanks is pumped to two units of triple-effect evaporators, each unit consisting of three pans; each pan is comprised of a heater, flashing chamber and vapor lines. The pans are 22 feet inside diameter by 85 feet high.

Process. The process used is evaporation and crystallization and is described in detail by John E. Teeple, Ph.D.[1]

The storage buildings have a capacity of 15,000 tons of borax and 12,000 tons of potash. Railroad cars run direct into storage buildings, where the crude and sacked products are loaded into cars for shipment.

The company also manufactures boric acid; the product produced amounts to 10 tons per day of refined boric acid, for use in the technical and chemical trade.

A total of 525 men is employed.

Bibl: State Mineralogist's Report XVII, pp. 357–358; Chamber of Mines & Oil Bull., July, 1919, 'Potash of Searles Lake,' by Alfred De Ropp, Jr.; American Chemical Society, Monograph Series, No. 49.

Borosolvay Plant. It is situated on the west shore of Searles Lake, 2½ miles south of Trona, at Borosolvay. Holdings comprise 1000 acres of patented ground. Owner, *Pacific Coast Borax Company.*

This plant was operated by the Solvay Process Company of New York from September, 1916, until 1920, when the operations were suspended. It is reported that the plant during this period of operation produced about 200 tons of potash per month. Idle.

Burnam Chemical Company. C. B. Burnam, president; E. D. Whitney, secretary. Offices: 433 California street, San Francisco, California.

The experimental plant of this company is located 4 miles south of Trona and 2 miles east of the west shore of the lake in the Crystal salt area. The camp and warehouse is located on the west shore of

[1] "The Industrial Development of Searles Lake Brines" in American Chemical Society Monograph Series, No. 49, published by Chemical Catalog Co., Inc., New York City.

the lake. The plant has a capacity of 50 tons per day. The process used is solar evaporation. The products recovered from the brines are borax, potash and glaserite ($3K_2SO_4Na_2SO_4$). The solar evaporation ponds cover 160 acres, which is divided up into 20-acre ponds.

The raw brine from these evaporation ponds is pumped to concentration ponds. The concentrated brine is then pumped to spray pond, equipped with Dorr thickener mechanism. The borax recovered in the plant is reported 99.5% pure. The borax was hauled by truck from this plant to warehouse on the west shores of the lake. The crude borax crystals were put through Raymond Pulverizer mill, dried and sacked for shipment. When the plant was under operation the output is reported to have been 15 tons per day for refined borax. Ten men are employed on construction work.

Solvay Process Company's plant. Borosolvay, Searles Lake, California.

SALT

Avawatz Salt and Gypsum Company, offices: Garland Building, Los Angeles, own large deposits of salt situated in the Avawatz Range of mountains about 12 miles west of Riggs, a station on the Tonopah and Tidewater Railroad. The salt is found in the deposits in enormous quantities. These salt deposits are known as Jumbo salt area, Salt Basin area and Valley salt area.

Rock salt of great purity is found in these areas; individual beds are over 50 feet thick, interstratified with insoluble clay, sand and anhydrite; total thickness and proportion of salt to insoluble material unknown. The salt is usually massive and does not show crystalline structure. The color is usually reddish or brown, though there are occasional seams of clear white salt. Chemical analyses show purity as high as 98%. These are places in the above-mentioned areas where the salt stands over 100 feet thick, above the canyon bottoms.

Approximate estimates of the tonnage of salt contained in the Avawatz Mountains:

Jumbo salt area	9,000,000 tons
Salt Basin area	8,000,000 tons
Valley salt area	5,000,000 tons

Deposits are undeveloped principally due to their inacessibility. Idle.

Bibl: State Mineralogist's Reports XVII, p. 357; XVII, p. 116; Bull. 24, pp. 126–128; U. S. Geol. Survey Bull. 540, pp. 526–530.

Cadiz Dry Lake Salt Deposits. These salt deposits are located in T. 2 and 3 N., R. 15 E., S. B. M., 12 miles west of Milligan, a station on the Santa Fe Railroad. The surface of Cadiz Dry Lake is made up of sand and clay mixed with gypsum. Test holes sunk in the lake bed encountered crystalline gypsum and salt with brine. The salt beds are from 5 to 7 feet thick. The gypsum and salt beds are interstratified with brown sand or sandy clay. The brines contain a considerable percentage of calcium chloride.

Bibl: U. S. Geol. Survey Bull. 578, p. 695; Bull. 669; Mineral Resources 1917 and 1920.

California Rock Salt Company. W. F. Bledenbach, president and manager; offices: 2465 Hunter street, Los Angeles. The plant is situated 6 miles east of Amboy at Saltus, a station on the Santa Fe Railroad. The salt and bittern pits are located 5 miles south of the plant on Bristol Dry Lake. The deposit of salt occurs on the south side of the lake. The salt beds are 8 feet thick, being overlain by 3 to 4 feet of sand and clay mixed with gypsum. The overburden is first removed by scrapers and gasoline-driven shovels. The material from salt pits is hauled by 20-h.p. gasoline-driven Plymouth locomotive, which hauls a train of 8 Western side-dump cars to the mill, a distance of 4 miles. The salt treated in the plant is crushed, washed and screened, the size of product being $\frac{1}{8}$-inch, $\frac{1}{4}$-inch and $\frac{1}{2}$-inch. The plant has a daily capacity of 100 tons of finished product. Products produced are salt and calcium chloride. Twelve men employed.

Bibl: State Mineralogist's Report XVII, p. 357; U. S. Geol. Survey Bull. 669.

Danby Dry Lake Salt Deposit. It comprises 660 acres of patented land located on Danby Dry Lake near Ward, a station on The Atchison, Topeka and Santa Fe Railroad on Parker cut-off. Owners, R. B. Evans of Pasadena and Russ Avery of Los Angeles, California.

A bed of salt from 8 to 15 feet in thickness occurs below the lake surface, being overlain with 3 to 5 feet of sand and clay mixed with gypsum.

The salt is quite pure, as analysis shows 98% sodium chloride. The estimated tonnage in this deposit is stated to be 25,000,000 tons. Two men employed.

Bibl: State Mineralogist's Report XVII, p. 357.

Saline Products Company, Inc., X. H. Hollar, vice president and manager; offices: 2000 Santa Fe avenue, Los Angeles, California.

The plant of this company is located at Funston, a siding on the Santa Fe Railroad, 5 miles south of Amboy.

The salt and bittern pits are located on the southern side of Bristol Lake, about 5 miles south of the plant.

The deposit of rock salt is 3 to 6 feet in thickness, being overlain with 4 feet of sand and clay mixed with gypsum.

A series of vats have been excavated by gasoline-driven shovels, being laid out in a general east and west direction. These vats are about 200 feet in width by 600 feet in length. Water from wells sunk on the lake is pumped by centrifugal pumps into these vats and the bittern is recovered by solar evaporation. Crude salt is loaded by gasoline-driven shovels into trucks having a capacity of 10 tons each. The trucks transport the salt across the lake to the plant. The

Saline Products Company salt plant, Bristol Lake, near Amboy.

rock salt is crushed, washed and screened in the plant, producing the following sizes: $\frac{1}{8}$-inch, $\frac{1}{4}$-inch and $\frac{1}{2}$-inch. The plant has a capacity of 100 tons of finished product per 10-hour day. Power to operate plant is developed by 200-h.p. Fairbanks-Morse diesel engine, directly connected to generator. Twenty-four men are employed at plant and pits.

SODA

Searles Lake, for many years an important source of borax and potash, is also the principal source of soda in the county. One plant, the West End Chemical Company, has been the principal producer of soda ash, which is recovered from the brines of Searles Lake.

Deposits of sodium sulphate occur at Dale Dry Lake near Dale, close to the southern boundary of San Bernardino and Riverside county. The occurrence of salt cake is also reported in the Dry Lake mining

district 60 miles east of Victorville. It is also reported to occur in the Old Dad Mountains, 10 miles southwest of Balch, a station on the Union Pacific Railroad.

Black Basin Sodium Sulphate Deposit. It comprises 10 claims situated in the Old Dad Mountains, 10 miles southwest of Balch, a station on the Union Pacific Railroad. Owner, C. W. Lipman, Story Building, Los Angeles.

A number of shallow prospect holes have been sunk in a wash which cuts across the claims. These holes have exposed 2 to 6 feet of sodium sulphate. Analysis shows 53% sodium sulphate.

Dale Dry Lake Deposit. This is the most important deposit of sodium sulphate in the county. The deposit is situated on Dale Dry Lake, 6 miles east of Dale and 15 miles east of Twenty-nine Palms.

Soda plant, West End Chemical Company, Searles Lake, San Bernardino County.

Holdings comprise about 1000 acres. Owner, J. E. Bush, Los Angeles, California.

The salts leached out by rain water have formed a layer, usually very thin, but in places filling deeper channels. Under this crust is a mud layer containing considerable of the salines in solution. The deposit is principally sodium sulphate, but with crystals of blödite, the hydrous sulphate of magnesium and sodium, associated with it. The deposit can be easily mined, but the long haul of 40 miles to Amboy makes marketing the product a difficult problem. The deposit has been thoroughly prospected by the owner, Mr. Bush. Idle.

Emerson Sodium Sulphate Deposit. This deposit is situated in a Dry Lake, in what is known as the Dry Lake Mining district about 60 miles east of Victorville. Owner, Mrs. L. S. Emerson, Hodge, California. Samples taken from the deposit are reported to carry 46.5% sodium sulphate.

West End Chemical Company. J. M. Smith, president; George C. Ellis, secretary; J. W. Sherwin, general manager; offices: Syndicate Building, Oakland, California.

The plant is on the west shore of Searles Lake, 4½ miles south of Trona. The property comprises about 2880 acres on Searles Lake. The concentrated brine is pumped from evaporation ponds to settling tanks. The brine from settling tank is pumped to 10 carbonate towers, 40 feet high by 8 feet in diameter, the process being to carbonate the liquors and so remove all of the sodium carbonate, as sodium bicarbonate or trona. This is filtered off and calcined to make soda ash.

The products produced in this plant are about 70 tons of soda ash per 24-hour day and about 25 to 30 tons of borax. Water to operate the plant is secured from springs located 17 miles west of the Lake. Dolomite to generate CO_2 gas is hauled by truck from a quarry owned by the company located north of Trona in Inyo County. Sixty-five men are employed.

STRONTIUM

Deposits of strontianite ($SrCO_3$) and celestite ($SrSO_4$) occur in San Bernardino County. Large deposits of celestite occur in the lake beds containing salt and gypsum in the Avawatz Mountains, on the holdings of the *Avawatz Salt and Gypsum Company,* Garland Building, Los Angeles. There is also a large deposit 4 miles north of Argos siding, on the Santa Fe Railroad and 6 miles from Ludlow. The beds of celestite are 12 feet to 20 feet thick. Strontianite, the carbonate, occurs in the clay beds 10 miles north of Barstow.

Bibl: State Mineralogist's Reports XV, pp. 898–899; XVII, pp. 366–367; U. S. Geol. Survey Bull. 540, pp. 526–531; 660–1.

TALC

Deposits of talc of commercial grade occur in the Avawatz Range of mountains and in the Shadow Mountains, northeast of Silver Lake; also southwest of Tecopa, east of the Amargosa River. The deposits in the Avawatz Mountains are undeveloped due to their distance from transportation.

The deposits in the vicinity of the Amargosa region, although they have been developed to a considerable extent, are idle at the present time, the only productive area being near Silver Lake, where the Tremolite Mine, operated by the Pacific Coast Talc Company of Los Angeles, has been an active producer since 1917. Over 80% of the talc produced in California in 1928 was high grade talc from Inyo and San Bernardino counties, which material was utilized mainly in toilet powders, paint, paper and rubber manufacture and some in ceramics. It is reported that the talc produced in San Bernardino county is steadily replacing imported talc in the toilet trade on the basis of quality.

The crude talc produced by the Pacific Coast Talc Company is a pure silvery white and has a foliated texture. The ground product is a clear silvery white, with a very good slip, no grit, and very little lime.

Deposits.

Amargosa Group of Talc Mines. It comprises two claims, situated 1¼ miles south of Acme, a station on the Tonopah and Tidewater Rail-

road. The deposit occurs in Painted Canyon, west of the Amargosa River. Owner, W. H. Hite, and Thomas Coghland of Tecopa, California. A vein 2 to 10 feet in width on contact of limestone and diorite. The vein has a north and south course, dip 45° east. The talc is silvery white in color and said to have low lime content. Development consists of two tunnels. Fifty-five cars of high grade talc was shipped from the deposit in 1919. Idle.

Bibl: State Mineralogist's Report XVII, p. 367.

Acme Talc Mine. It is situated 7 miles east of Acme Siding on the Tonopah and Tidewater Railroad, and 8 miles southwest of Tecopa, in a range of hills east of the Amargosa River. Holdings comprise 6 claims. Owner, *Western Talc Company,* 1901 E. Slauson avenue, Los Angeles.

Deposits of pure white talc of good quality occur along a contact of limestone and diorite. The general strike of the ore deposits is N. 30° W., dip 45° E. The outcrop shows a width of 20 to 50 feet. Developments consist of tunnels and open cuts—the tunnels are from 200 to 500 feet in length. A large tonnage was produced from this property during 1919 and 1920, when it was operated by the *Pacific Minerals and Chemical Company,* Glendale, California. Eight men are employed. Ore mined is shipped to company's grinding plant at Los Angeles.

Bibl: State Mineralogist's Report No. XVII, p. 367.

Gould Talc Deposit. It is situated in T. 17 N., R. 10 E., 10 miles northeast of Silver Lake, on west slope of Shadow Mountains. Owner, George Novell of Los Angeles. The deposit lies on and near contact of limestone and diorite and can be traced along its outcrop for 3000 feet. The talc that occurs along this contact is from 5 to 8 feet wide, is white in color, and reported to have low lime content. Development consists of a number of shafts from 30 to 40 feet deep. Idle.

Bibl: State Mineralogist's Report XVII, p. 368.

Sheep Creek Deposits. These deposits are situated in the Avawatz Range of mountains, 12 miles west of Riggs, a station on the Tonopah and Tidewater Railroad. Owner, *Avawatz Salt and Gypsum Company,* Garland Building, Los Angeles.

The talc deposits of this region occur on contact of limestone and diorite. The talc is pure white to light gray in color, and varies in hardness from solid outcrops, which are moderately hard, to very soft crumbly masses. The fibrous and nonfibrous material, talc and tremolite, is silvery white in color and quite pure. The general strike of the outcrops that occur on Sheep Creek is northwest and southeast, and they vary in width from 15 to 35 feet.

There are four deposits in this region, three being on Sheep Creek and the fourth is northwest of the Jumbo-Salt deposit. The estimated tonnage that can be mined from these deposits is 400,000 tons. Idle.

Bibl: State Mineralogist's Reports XVII, pp. 368–369; XVIII, pp. 114–115.

Talc Products Company Deposit. The deposit is situated in the Shadow Mountains, 2¼ miles east of Love Siding on the Tonopah and Tidewater Railroad. The deposit of talc occurs on the contact of

limestone and diorite, which strikes northwest and southeast. The deposit has a thickness of 5 to 8 feet. The talc is slippery and foliated, pure white in color. Idle.

Bibl: State Mineralogist's Report XVII, p. 369.

Tremolite Mine (Pacific Coast Talc Company's Deposit). The property is situated on the northwest slope of Shadow Mountains, 10 miles northeast of Silver Lake and 7 miles southeast of Riggs, a station on the Tonopah and Tidewater Railroad. Elevation 2300 feet. Holdings comprise 14 claims, totaling 280 acres. Owner, *Pacific Coast Talc Company,* 2149 Bay street, Los Angeles. W. S. Lockhart, president; A. M. Algeo, secretary; George Ames, general manager.

The deposit of talc occurs in ferro-magnesium schists on or near the contact of limestone and diorite and has a general course of northwest and southeast, and can be followed along its outcrop for a distance of nearly one mile. The vein of talc dips 57° south, and has a thickness of 5 to 10 feet, the ore occurring in irregular shoots. The talc mined is remarkable for its whiteness, mode of occurrence, and its origin. The crude talc is a pure silver white, with very good slip, no grit, and very little lime. The deposit has been developed by three incline shafts sunk on the vein on different portions of the property to depths of 120 to 150 feet; present work confined to a tunnel 1700 feet in length of which 1200 feet is driven on the vein. It is reported that there is about 50,000 tons of ore developed above the tunnel level. The ore mined from stopes above the tunnel level is trammed in cars to storage bin. The ore is hauled by motor truck to Riggs, the nearest shipping point, from which it is loaded in railroad cars and shipped to the company's grinding plant in Los Angeles. The grinding plant has a capacity of 20 tons per 10-hour day. The finished product is very high grade; it is extremely fine, has no grit; an excellent color; a very good slip, and adhers well to the skin. A typical analysis shows 0.31% lime (CaO) and 0.28% iron oxide. Products are utilized in the manufacture of talcum powder, roofing paper, paint trade, tiling and concrete admixture. Twelve men employed.

Bibl: State Mineralogist's Report XVII, pp. 369–370; XXVII, pp. 100–104; U. S. B. M. Bulletin 213, pp. 116–117.

GEOLOGIC BRANCH

Olaf P. Jenkins, Chief Geologist

Progress Report.

Since the recent appearance of the preliminary edition of Bulletin 104 ('Bibliography of the Geology and Mineral Resources of California to the End of 1929'), Solon Shedd, its author, has been revising the book in accordance with much new information received, including all references for the year 1930. He is also undertaking the monumental task of cross-indexing the bibliography so that one may readily find references to all sorts of articles (geology, geography, physiography, paleontology, mineralogy, mining and oil geology, etc.), which cover any area of the State.

Several geological papers prepared by able geologists have recently been submitted for publication in Mining in California. Several other articles, based on recent field work, are now in the course of preparation. It is gratifying to watch the growing interest in the State's geological survey and the constant desire on the part of geologists to help develop the State's work through personal contributions.

So far as limited funds have permitted, partial field expenses have been contributed by the Division of Mines for special investigations. These, however, have been limited largely to investigations started previously, but not yet completed. They are as follows:

(1) Weaverville quadrangle (Shasta and Trinity counties) by N. E. A. Hinds.

(2) Elizabeth Lake quadrangle (Los Angeles and Kern counties) by E. C. Simpson.

(3) Searles Lake quadrangle (San Bernardino, Inyo and Kern counties) by C. D. Hulin.

(4) Sebastopol and Duncans Mills quadrangles (Sonoma and Marin counties) by F. A. Johnson.

(5) Amboy quadrangle (San Bernardino County) by J. C. Hazzard.

(6) Newberry and Ord Mountains (San Bernardino County) by Dion Gardner.

(7) Northeastern Madera County by Homer Erwin.

Besides these problems, the study of the geology of the Hetch Hetchy aqueduct tunnels through the Coast Range is being continued by George Green.

Detailed reports on the geology of the San Jacinto quadrangle by D. M. Fraser, and of the east flank of the Sierra Nevada in Mono County by E. B. Mayo are in preparation for publication.

Several new investigations have been started in various parts of the State, and the Geologic Branch had hoped to assist in these problems but funds would not permit. The studies have, therefore, been foreshortened in some cases. In many other cases, proposed investigations

have been withdrawn on account of lack of funds to support the few hundred dollars necessary for field expenses.

In combining the efforts of both the Geologic Branch and the Mining Division, a special investigation of the Carmel building stone is being carried on by Wayne Galliher of the Hopkins Marine Station (Stanford University) at Pacific Grove.

A considerable amount of geological information of California has been correlated and brought together by various authors to form a guidebook to be used by the International Geological Congress during its extensive excursion through the United States in 1933. The Chief Geologist of this division is chairman of the central and northern Californian committee of the congress and is working under the general direction of the executive committee which is located in the office of the U. S. Geological Survey in Washington, D. C.

The new geological map of the State of California is making notable progress. Information has already been taken from it and is being used to form the new geologic map of the United States in preparation by the U. S. Geological Survey for use by members of the International Geological Congress. The State map is proving to be an extremely interesting and useful piece of work and in its construction many new problems are constantly arising. If this much needed compilation and coordination of useful data had been left undone much longer a large quantity of the material would have been lost in the general confusion of disconnected detail, much of which at the present time lies unpublished in the files of various departments of geology.

A number of field trips have been made by the Chief Geologist in company with specialists of various branches of geological research into the more or less unknown parts of northern California. Through the courtesy of William Morris Davis (Professor Emeritus, Harvard University) and as a result of some of these northern Californian excursions, there will appear in an early issue of Mining in California a very interesting and instructive article on physiography. Its author, Dr. Davis, is famed throughout the world as a geographer and geologist.

OIL FIELD DEVELOPMENT OPERATIONS

R. D. Bush, State Oil and Gas Supervisor.

From March 29, 1931, to and including June 27, 1931, the following new wells were reported as ready to drill:

Company	Sec.	Twp.	Range	Well No.	Field
ALAMEDA COUNTY:					
Hayward Oil Co., Ltd.	29	3	1	1	
COLUSA COUNTY:					
William P. Jackson	8	17	3	1	
Smith & Vickers	28	16	2	1	
FRESNO COUNTY:					
W. L. Denton	26	20	14	8	Coalinga
William Pearce	6	20	15	7	Coalinga
Superior Oil Co.	29	21	17	Huffman 3	Kettleman Hills
HUMBOLDT COUNTY:					
Schaufele & Reynolds	1	3	1	1	
IMPERIAL COUNTY:					
D. H. Wood	7	11	16	Melson 1	
KERN COUNTY:					
Sea Hawk Petroleum Co., Ltd.	23	29	27	A 1	Fruitvale
Universal Consolidated Oil Co.	30	26	21	17-D	Lost Hills
California Oil Producers, Ltd.	30	30	22	Cal. Oil Prod.-MM 1	McKittrick
Hugh B. Evans, Inc.	35	32	23	11	Midway
Hugh B. Evans, Inc.	35	32	23	12	Midway
Hugh B. Evans, Inc.	35	32	23	15	Midway
Fred D. Turner, Trustee	22	32	23	Bull 1	Midway
C. C. M. O. Co.	26	27	28	Mon 2	Mt. Poso
General Petroleum Corp.	16	27	28	Heisen 27	Mt. Poso
General Petroleum Corp.	16	27	28	Heisen 28	Mt. Poso
General Petroleum Corp.	16	27	28	Heisen 34	Mt. Poso
C. C. M. O. Co.	6	28	29	3	Round Mountain
Golden Bear Oil Co., Ltd.	6	28	29	2	Round Mountain
Golden Bear Oil Co., Ltd.	6	28	29	3	Round Mountain
Golden Bear Oil Co., Ltd.	6	28	29	4	Round Mountain
Golden Bear Oil Co., Ltd.	6	28	29	5	Round Mountain
Golden Bear Oil Co., Ltd.	6	28	29	6	Round Mountain
Cumberland Oil Co.	17	26	18	Cumberland 2	
Kendall Development Co., Ltd.	27	11	9	1	
L. C. Osborn	15	30	29	Duff 1	
KINGS COUNTY:					
Bolsa Chica Oil Corp.	30	23	19	Downing 30 2	Kettleman Hills
Howard L. Bryan	26	21	17	1	Kettleman Hills
Powell-Stockton Inv. Co., Ltd.	32	22	19	1	Kettleman Hills
Utah-California Petroleum Development Co.	13	24	18	1	Kettleman Hills
Kettleman Lake View Oil & Gas Co.	11	23	19	2	
LOS ANGELES COUNTY:					
Rosenberg & Robbins	7	2	14	9	Inglewood
Standard Oil Co.	17	2	14	L. A. Inv. 1 66	Inglewood
Pacific Shore Oil Co., Ltd.	20	3	14	1	Lawndale
Chiksan Oil Co., Ltd.	13	4	13	Wolter 2	Long Beach
Cooperative Petroleum Co., Ltd.	30	4	12	1	Long Beach
Covington Oil Co., Ltd.	29	4	12	1	Long Beach
W. T. Ball	34	4	16	1	Newhall
Union Oil Co.	28	2	15	Del Rey 3	Playa del Rey
Union Oil Co.	28	2	15	Townsite 10	Playa del Rey
Union Oil Co.	28	2	15	Townsite 11	Playa del Rey
Taylor Oil Co., Ltd.	28	2	14	2	Potrero
Wilshire Annex Oil Co.	34	2	14	1	Potrero

OIL FIELD DEVELOPMENT OPERATIONS—Continued

Company	Sec.	Twp.	Range	Well No.	Field
LOS ANGELES COUNTY—Cont.					
Bell View Oil Syn.	6	3	11	Santa Fe 6	Santa Fe Springs
Union Oil Co.	6	3	11	Bell 63	Santa Fe Springs
Cone & Smith	6	4	14	Kellogg & Burdick 2	Torrance
Cone & Smith	6	4	14	Kellogg & Burdick 3	Torrance
S. H. Human	6	4	14	1	Torrance
W. S. Ewert	29	4	13	1	
W. S. Ewert	20	4	13	2	
W. S. Ewert	20	4	13	3	
W. S. Ewert	20	4	13	4	
Mrs. Fred Lehman	28	4	13	1	
The Lucky Four Syn.	29	4	13	1	
The Lucky Four Syn.	29	4	13	2	
McCoy and Associates	28	4	13	1	
McCoy and Associates	28	4	13	2	
McCoy and Associates	28	4	13	3	
McCoy and Associates	28	4	13	4	
McCoy and Associates	28	4	13	5	
McCoy and Associates	28	4	13	6	
McCoy and Associates	28	4	13	7	
McCoy and Associates	28	4	13	8	
McCoy and Associates	28	4	13	9	
McCoy and Associates	28	4	13	10	
McCoy and Associates	28	4	13	11	
McCoy and Associates	28	4	13	12	
McCoy and Associates	28	4	13	13	
McCoy and Associates	28	4	13	14	
McCoy and Associates	28	4	13	15	
McCoy and Associates	28	4	13	16	
O. C. O. Oil Co.	14	3	16	1	
Pedro Petroleum Corp., Ltd.	14	5	14	1	
George J. Tighe	28	4	13	1	
Yellowstone Oil Co., Ltd.	19	1	12	Yellowstone-Castruccio 1	
ORANGE COUNTY:					
Armor Petroleum, Ltd.	34	5	11	1	Huntington Beach
Isador Fields Co.	10	6	11	Fields 1	Huntington Beach
Ben F. Mun	34	5	11	Mun H. B. Fee 1	Huntington Beach
Ben F. Mun	34	5	11	Mun H. B. Fee 2	Huntington Beach
P. H. Osborne	10	6	11	1	Huntington Beach
Republic Petroleum Co.	10	6	11	Huntington Beach 1	Huntington Beach
H. M. Bergen	33	3	9	1	Richfield
H. Cohen	20	5	11	Cohen 1	
H. Cohen	20	5	11	Cohen 2	
H. Cohen	20	5	11	Cohen 3	
H. Cohen	20	5	11	Cohen 4	
Walter F. Larson	20	5	11	Cavanaugh 1	
R. W. Manker	20	5	11	Manker 1	
McAleer Gun Club Syn.	21	5	11	1	
McGowan & Thomas	20	5	11	1	
McGowan & Thomas	20	5	11	2	
George E. Miller	20	5	11	1	
R. R. Richey	20	5	11	1	
R. R. Richey	20	5	11	2	
Albert C. & Eleanora D. Sellery	20	5	11	1	
Eleanora D. Sellery	20	5	11	1	
M. D. Skroopka	20	5	11	Skroopka 1	
Whittier-Santa Fe Springs Oil Syndicate No. 1	20	5	11	1	
RIVERSIDE COUNTY:					
Frank Beck	14	3	1	2	

OIL FIELD DEVELOPMENT OPERATIONS—Continued

Company	Sec.	Twp.	Range	Well No.	Field
SAN DIEGO COUNTY:					
Itasca Petroleum Co., Ltd.	33	18	1	1	
South Bay Oil & Gas Co., Ltd.	31	18	2	James N. Crafton 1	
SAN LUIS OBISPO COUNTY:					
Cities Service Petroleum Co., Ltd.	20	28	15	Fay 1	
A. T. Jergins Trust	27	31	12	1	
SANTA BARBARA COUNTY:					
Pacific Western Oil Co.	16	4	29	92-8	Elwood
W. Ernest Smith et al.	18	7	34	1	
Southern California Drilling Co.	7	4	28	Bishop 1	
Charles Stark	28	4	27	Nye 1	
Charles Stark	28	4	27	Ross 1	
Universal Royalties, Ltd.	28	4	27	1	
Zaca Oil Co., Ltd.	20	7	31	Zaca 1	
SANTA CLARA COUNTY:					
Sargent Oil Co., Ltd.	1	12	3	1-A	Sargent
STANISLAUS COUNTY:					
Bud Hildebrand	36	6	7	1	
TULARE COUNTY:					
L. L. Ellis and M. U. Stanford	20	24	23	1	
L. L. Ellis and M. U. Stanford	20	24	23	2	
Fred N. Gholson	3	23	27	Chamboy 1	
VENTURA COUNTY:					
General Petroleum Corp.	8	3	24	Ferguson 3	Rincon
Mahlon H. Wolff	6	2	17	Loomis 1	Simi
Associated Oil Co.	26	3	23	Lloyd 83	Ventura
Associated Oil Co.	26	3	23	Lloyd 109	Ventura
Associated Oil Co.	26	3	23	V.L.&W. 18	Ventura
Associated Oil Co.	27	3	23	Lloyd 81	Ventura
Associated Oil Co.	27	3	23	Lloyd 111	Ventura
Associated Oil Co.	27	3	23	Lloyd 129	Ventura
Mex Cal Oil & Refining Co., Ltd.	12	1	20	1	
Nelson Jensen Hansen	24	1	20	Hansen 1	

SPECIAL ARTICLES.

Detailed technical reports on special subjects, the result of research work or extended field investigations, will continue to be issued as separate bulletins by the Bureau, as has been the custom in the past.

Shorter and less elaborate technical papers and articles by members of the staff and others are published in each number of MINING IN CALIFORNIA.

These special articles cover a wide range of subjects both of historical and current interest; descriptions of new processes, or metallurgical and industrial plants, new mineral occurrences, and interesting geological formations, as well as articles intended to supply practical and timely information on the problems of the prospector and miner, such as the text of new laws and official regulations and notices affecting the mineral industry.

FELDSPAR, SILICA, ANDALUSITE AND CYANITE DEPOSITS OF CALIFORNIA

By REID J. SAMPSON and W. B. TUCKER

FELDSPAR

Production.

The first recorded production of feldspar in California was in 1910. In that year 760 tons, having a value of $5,720 were produced. In 1929 the production was 13,327 tons, valued at $78,404. Total production through 1930 has amounted to 124,142 tons with a valuation of $797,129. All of the 1930 production was from Kern, Riverside and San Diego counties.

Total Feldspar Production in California.

Total amount and value of feldspar production in California since the inception of the industry are given in the following table, by years.

Year	Tons	Value	Year	Tons	Value
1910	760	$5,720	1921	4,349	$28,343
1911	740	4,560	1922	4,587	37,109
1912	1,382	6,180	1923	11,100	81,800
1913	2,129	7,850	1924	9,055	68,112
1914	3,530	16,565	1925	8,165	59,615
1915	1,800	9,000	1926	7,300	56,400
1916	2,630	14,350	1927	10,932	86,101
1917	11,792	46,411	1928	14,628	93,745
1918	4,132	22,061	1929	13,327	78,404
1919	1,272	12,965	1930	5,104	35,654
1920	4,518	26,189			
			Totals	124,142	$797,129

The total production[1] of crude feldspar in the United States for the year 1929 was 197,699 long tons, valued at $1,276,640 or an average value of $6.46 per ton, as compared with $6.72 in 1928 and $7.04 in 1927.

Crude feldspar was produced in twelve states in 1929: Arizona, California, Colorado, Connecticut, Maine, Maryland, New Hampshire, New York, North Carolina, Pennsylvania, South Dakota and Virginia. North Carolina produced 52% of the total (103,273 tons), New Hampshire was second with 30,964 tons and Maine third with 19,992 tons.

Importations into the United States in 1929 amounted to 29,927 tons, valued at $241,852, an average of $8.08 per ton. These shipments practically all came from Canada.

Important producing countries other than the United States and Canada are Germany, Norway, Russia and Sweden. Apparently there has been no production in recent years in Great Britian, where 'Cornwall stone' has been substituted for feldspar as a flux in the pottery industry.

Before proceeding with descriptions of the various deposits in California, a brief discussion of the minerals, their occurrence, uses, markets and preparation is given.

GENERAL DESCRIPTION

Feldspar.[2]

Under this name there has been grouped a number of minerals, which while differing somewhat in their chemical composition, have remarkably similar physical properties.

The feldspars are silicates of aluminium with either potassium, sodium or calcium and rarely barium. Chemically, they may be divided into four groups, according to their alkaline constituent.

Potash feldspar, known as microcline or orthoclase, $KAlSi_3O_8$; soda feldspar, known as albite $NaAlSi_3O_8$; lime feldspar, known as anorthite, $CaAl_2Si_2O_8$; barium feldspar, known as celsian, $BaAl_2Si_2O_8$.

Feldspars actually conforming to the above formulae are rarely found in nature. Usually they occur as intimately crystallized masses of two or more different varieties. Or some of them may combine to form homogeneous crystals of definite composition, whereas others are isomorphous.

Due to the last-mentioned habits of these minerals, we have the plagioclase feldspars. This is an intermediate series beginning with albite (soda feldspar) through soda-lime, lime-soda varieties to anorthite (lime feldspar). With the acquisition of more than 3% lime, albite becomes a soda-lime feldspar, while a soda content in excess of 1.6% places anorthite in the lime-soda subgroup. Four members of this subgroup have been recognized, oligoclase, andesine, labradorite and bytownite, while anorthoclase, a soda-potash variety is intermediate between microcline and albite and sanidine is a soda-orthoclase variety.

The feldspars all crystallize in either the monoclinic or triclinic systems. The soda-lime, lime-soda, or plagioclase group crystallize in the triclinic as do also microcline and anorthoclase, while orthoclase and soda-orthoclase are monoclinic. The hardness varies from 6 to 6.5

[1] Mineral Resources of U. S. 1929, Part II, pp. 79–80.

[2] In the general discussion of these minerals, Bull. 92 of the U. S. Bureau of Mines and 'Non-Metallic Minerals' by Ladoo have been drawn upon freely.

and specific gravity from 2.5 to 2.9. All feldspars have a good cleavage in two directions at 90° or nearly 90° apart. Feldspars are found in a great variety of colors, the most common of which are white, gray, salmon pink, brown, yellow and green. The melting point varies from 1185° to 1490° C.

The potash feldspars are those most extensively used in the industries. These are microcline and orthoclase. Of these two, contrary to popular belief, microcline is the more common. This fact, however, has no practical significance as the composition and physical properties of the two are identical.

The 'potash feldspar' of commerce really consists of microcline and albite or microcline and soda-lime members of the plagioclase group.

There are no known deposits of commercial size of albite (soda feldspar). So that the manufacturer who buys 'soda feldspar' does not get true albite but a feldspar which has a high-soda content and a comparatively small amount of potash and lime.

PYROMETRIC PROPERTIES OF VARIOUS FELDSPAR MIXTURES

Research work has been conducted by the United States Bureau of Mines to determine what effect variations in chemical composition have on physical properties of feldspars. Also tests on various mixtures of feldspar with quartz, beryl, muscovite, biotite and kaolin.

[1] "The impression prevails among users of feldspar that 'soda feldspar' or albite is the softest member and 'potash feldspars' or microcline is the hardest member of a feldspar series, and that the hardness of any mixture of these two will be proportionate to its relative content of the two extremes; that is, the deformation-temperature curve of potash feldspar-soda feldspar mixtures is supposed to be a straight vertical line with soda feldspar as the lowest point and potash feldspar as the highest point.

"The results of a study by the writer of a large number of feldspars containing both potash and soda as fluxes indicate that this assumption is not true, but in making feldspar analyses there are so many slight variables which may affect the result that the exact cause of variation in any particular property is extremely difficult to determine. However, it was noted that feldspars with a moderately-high content of soda and a proportionately low content of potash showed a marked tendency to deform at lower temperature than did the relatively pure soda feldspars * * *."

Results of tests showed that a mixture consisting of 69% albite and 29% microcline begins to deform at a lower temperature and the deformation is completed in less time than any other mixture which was tested in the potash-soda series.

It was also shown that an increase in the percentage of microcline over that contained in the eutectic mixture decreases the rate of deformation, the potash-feldspar end of the series requiring twice as much time for deformation as the albite.

"Thus it is shown that a high soda content does not indicate a low deformation temperature. Also the approximate proportion of soda feldspar can not be determined except by a careful observation of the rate of deformation."

Tests on mixtures of potash feldspar and quartz showed that the deformation eutectic of these minerals consists of 90% feldspar and 10% quartz. The pure feldspar deformed at the same temperature and rate as a mixture containing 95% feldspar and 5% quartz, and there was no noticeable difference in the behavior of the cones until a mixture consisting of 80% feldspar and 20% quartz was reached.

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[1] Watts, A. S., The Feldspars of the New England and North Appalachians States, U. S. Bureau of Mines, Bull. 92, p. 32, 1916.

A mixture consisting of 65% feldspar and 35% silica is scarcely more than one-half cone harder than the pure feldspar.

"Feldspar, high in potash and very low in soda content is only slightly affected by additions of quartz or flint. Substitution of quartz for feldspar in proportions up to 20% may be made without materially affecting the temperature at which deformation begins or is completed. Substitution of quartz for feldspar up to 35% may be made without affecting the deformation temperature more than one-half cone.

"The foregoing indicates the futility of attempting to ascertain the extent to which a feldspar is adulterated with quartz by the deformation test alone."

Tests on mixtures of soda-feldspar and quartz gave different results from those obtained from the potash feldspar. It was found that there was no difference, in the temperature at which deformation began or was completed, between the pure soda feldspar and mixtures containing up to 30% quartz.

"A mixture of 75% soda feldspar and 25% quartz, however, deformed more quickly after its deformation temperature was reached than did the pure soda feldspar. The rate of deformation, as indicated by the time intervals, is more rapid with soda feldspar and with all mixtures of soda feldspar and quartz than with potash feldspar or any mixture of potash feldspar and quartz."

Tests were made also on mixtures of 'commercial potash feldspar' and quartz. This material contained 50% more soda feldspar than that used in the potash feldspar tests above described.

Composition of commercial potash feldspar used in test:

	Per cent
H_2O	0.17
SiO_2	65.37
Al_2O_3	17.92
Fe_2O_3	0.02
TiO_2	Trace
CaO	0.17
MgO	Trace
BaO	0.15
K_2O	13.05
Na_2O	2.10
	98.95

"The cones against which this series was tested included pyrometric cones 8 and 9, whereas the soda feldspar-quartz series was within the range of standard cones 9 and 10. Therefore this feldspar falls between the other two although a careful study of the results obtained reveals the fact that it more nearly approaches in behavior the regular potash feldspar than the soda feldspar.

"* * * The rates of deformation of the mixtures are somewhat faster than those of the pure potash feldspar-quartz mixtures but are much slower than those of the pure soda feldspar-quartz mixtures."

General conclusions drawn from these feldspar-quartz deformation tests are:

"* * * it appears that pure potash feldspar may be expected to deform at about cone 10 and that adding 10% of quartz lowers the deformation temperature to a noticeable extent but does not increase the rate of deformation.

"If a small proportion of the potash feldspar is replaced by soda feldspar (2% Na_2O), the mixtures with quartz do not in any case begin to deform at a lower temperature than the feldspar. However, a mixture of 95% feldspar and 5% quartz begins to deform at the same temperature as pure feldspar but completes deformation in slightly less time. A 90 to 10 mixture begins to deform at a noticeable interval after the pure feldspar and the 95 to 5 mixture, but completes deformation at the same time as the 95 to 5 mixture. Thus a 90 to 10 mixture has a greater rate of deformation than the potash-soda feldspar itself. All mixtures of this feldspar with quartz show a tendency to deform more rapidly after deformation begins than does the pure feldspar.

"The soda feldspar-quartz mixtures show no evidence of having lower deformation temperatures than pure soda feldspar, and increasing the quartz content of the mixture increases with noteworthy regularity the temperature at which deformation begins. However, a mixture of 75% soda feldspar and 25% quartz deforms more rapidly after deformation begins and in all mixtures of soda feldspar and quartz, and also pure soda feldspar, deformation proceeds more rapidly after it begins than in potash or potash-soda feldspar or any of the mixtures with quartz."

Deformation tests were also made on mixtures of feldspar and muscovite (white mica). It was found that a mixture of 95% feldspar and 5% muscovite begins to deform before any other mixture tested. But the rate of deformation increased with increase of muscovite. Also that the mixture 95 to 5, which had the slowest rate of deformation, touched the plate just as the pure feldspar shows the first indication of deformation. In other words, the addition of a finely ground muscovite to microcline lowers the deformation temperature and increases the rate of deformation.

The most important consideration in the presence of muscovite is the color. It was found that feldspar mixtures containing up to 1 per cent muscovite retained their original color.

"DEFORMATION TESTS OF FELDSPAR-BIOTITE MIXTURES[1]

"As biotite (black mica) is a constituent of practically every pegmatite dike and is considered by users of feldspar as an injurious, if not the most injurious, associate mineral, it is important to know the effect of biotite on the pyrometric properties of feldspar.

"Biotite has the composition $K_2O4MgO2Al_2O_3,6SiO_2$, in which MgO may be replaced in part by FeO and Al_2O_3 by Fe_2O_3 the depth of color being determined by the extent of this replacement.

"A series of feldspar and biotite mixtures was prepared by pulverizing each of the minerals until it passed a 200-mesh bronze sieve, mixing them in the proper proportions, and regrinding each mixture carefully to insure as intimate a mixture as possible. The mixtures were made into cones of standard dimensions and these were tested against standard pyrometric cones for deformation temperature and rate of deformation. * * *"

"The results indicated that an eutectic mixture is formed with about 90% feldspar and 10% biotite. The feldspar alone deformed at about cone 7, indicating that biotite causes a pronounced lowering of the deformation temperature. The rate of deformation is not noticeably affected. The coloring action of the biotite is a complete barrier to the use of biotite-bearing feldspar in most ceramic industries, as 1 per cent of biotite colors the fired feldspar a pronounced gray and 2 per cent produces a dark gray-brown color. The mixtures containing 5 per cent biotite show a tendency to boil when deformation begins, a characteristic of mixtures containing an excess of magnesium."

Tests were made to determine the effect of kaolin on commercial feldspar by Hewitt Wilson, ceramic engineer, in preparing data for a thesis at Ohio State University.[2]

Kaolin was added to feldspar in one per cent intervals from 0 to 16% and above this, 25%, 30%, 35%, 40% and 45%.

The results obtained indicated that there are two deformation eutectics, the lesser in the region of 2 to 3% kaolin and 98 to 97% feldspar, and the greater at 9 to 11% kaolin and 91 to 89% feldspar.

Around 2 to 3% the start of deformation is slightly later than the pure feldspar, the rate is faster, the end being reached before that of pure feldspar.

At 5 to 6% the rate is about the same as the pure feldspar but the start and end of deformation are behind the feldspar.

From 9 to 11% there is another slow start, rapid rate and quick finish to deformation. The rate here is faster than any other.

"Beyond 10% kaolin, normal conditions are gradually resumed the start and finish progressing toward higher temperatures with the increase of kaolin."

For further information and details concerning the above tests the reader should refer to Bulletin 92, United States Bureau of Mines,

[1] Watts, A. S., U. S. Bureau of Mines, Bull. 92, pp. 44–46.
[2] Wilson, Hewitt, Deformation study of feldspar-kaolin mixtures; Trans. Am. Cer. Soc., Vol. 15, pp. 217–232, 1913.

'The Feldspars of the New England and North Appalachian States,' by A. S. Watts, published in 1916.

Occurrence.

The feldspars are the most abundant of all minerals and it has been estimated that they constitute some 60% of the igneous rocks. Since the potash and soda varieties are the feldspars of commerce, it is with them that we have to deal. These occur chiefly in pegmatite dikes in granite. The pegmatite, which is simply a coarsely crystalline aggregate of the same minerals that constitute granite, may, however, consist entirely of feldspar and quartz, the other minerals of the granite being totally absent. If the crystallization is very coarse or if, as sometimes happens, the constituents of the dike are separated into distinct bands, it is possible to mine the feldspar without its being too greatly contaminated by the associated minerals. It is thus that commercial deposits of feldspar occur.

The origin of pegmatite dikes or veins (according to Kemp it is a question as to which is the better term) has been explained in various ways. It is generally believed that they are parts of the same general magma as the granite, having been intruded, from the partly-solidified mass into openings formed by gases and vapors or into contraction cracks in the crust of the cooling granite. As a result of such origin they almost invariably occur as a series of lenses, frequently expanding into wide bodies or contracting to a mere seam in the space of a few feet.

The crystalline structure of the dikes is subject to the same sudden changes as its width. In a few feet it may change from a structure, in which the various minerals are segregated into distinct bands, to an intimately interwoven mass of feldspar and quartz, or feldspar, quartz and biotite or muscovite (more frequently the biotite).

These vagaries in size and structural conditions make the mining of the deposits a difficult problem, so that the installation of proper machinery for the economical extraction of the feldspar is not always warranted by the amount of material in sight, and the uncertainty of its persistence adds to this difficulty.

Some of these dikes, at the surface, are such a coarsely-crystalline, clean pegmatite, as to permit sorting of clean feldspar but at a few feet in depth the iron-bearing minerals appear and the dike changes to a coarse hornblende or biotite granite, finally merging into a fine-grained, normal granite. Frequently a study of the outcrop will give warning of such a condition, as the same changes will probably be found along the strike of the dike.

To date, mining of feldspar in the United States has resulted in the waste of large quantities of material which might readily have been used. This condition has obtained by reason of the fact that each individual deposit is usually mined to supply a certain definite market or user and grades unsuitable for that particular use have, in most instances, been thrown on the dump, there to be mixed with other waste, making its recovery an economical impossibility.

In this connection it is well to note that the enormous whiteware industries of Staffordshire, England, use exclusively the coarse granites or pegmatites of Cornwall. Their success with this material has led to the annual importation of thousands of tons of 'Cornwall stone'

into the United States for manufacturers who have found it more suitable for their products than any of the domestic feldspars.

It is a foregone conclusion that a considerable part of the American supply must eventually come from similar sources in this country.

Uses and Preparation.

A table showing how the consumption of feldspar in the United States is divided between the various industries is reprinted below from 'Non-Metallic Minerals,' by Ladoo.

	Per cent
Ceramic industries	84.0
Roofing and cement surfacing	6.0
Cement manufacture	5.0
Scouring soaps and abrasives	2.5
Ceramic binders for emery wheels, etc.	2.0
Chicken grits	0.5
Total	100.0

In the ceramic industries the use in pottery is the most important. Most whiteware bodies consist of from 10 to 35% feldspar and glazes usually contain 30 to 50% of feldspar. In general, the pottery trade demands that the percentage of free silica associated with the feldspar be less than 20% and in some cases specifications call for less than 5%.

The following is quoted from Commercial Standard CS23–30 of the U. S. Department of Commerce, Bureau of Standards:

"I. SCOPE

"This commercial standard classification covers ground feldspar used in the production of ceramic products, based on particle size and chemical composition. It is to be regarded as a classification rather than a definite purchase specification.

"II. GENERAL REQUIREMENTS

"All screen tests shall be made on standard screens (U. S. standard sieve series), the opening sizes of which are appended in Table 1. A standard method of screen testing is described on page 4.

"A standard method of chemical analysis is described, beginning on page 4.

"III. DETAIL REQUIREMENTS

"A. PHYSICAL CLASSIFICATION BASED ON FINENESS OF GRINDINGS[1]

TABLE 1

United States standard sieve series No.	*Percentage remaining on No. 200 sieve*	*Maximum percentage on sieve designated*	*United States standard sieve series (opening in inches)*
230	0.00– 0.35	1.0	0.0024
200	0.35– 1.00	1.0	.0029
170	1.00– 2.50	1.0	.0035
140	2.50– 5.00	1.0	.0041
120	5.00– 9.00	1.0	.0049
100	9.00–14.00	1.0	.0059
80	14.00–21.00	1.0	.0070
60	21.00–30.00	0.6	.0098
40	30.00–42.00	0.3	.0165
20	42.00–62.00	None	.0331

"B. CHEMICAL CLASSIFICATION BASED ON COMPOSITION AS IT INFLUENCES USE

"The numbers designated herein are for the purpose of illustration and the various groups may be added to, up or down the scale, to provide for all commercial grades of feldspar.

[1] Fineness classification shall be made on a basis of the percentage remaining on the standard 200 sieve and that remaining on the sieve designated. Example: 140-sieve product will have 2.5 to 5.00 per cent remaining on the 200 sieve and less than 1 per cent on the 140 sieve.

"GROUP 1

"The first group includes the commonly accepted ceramic or body grades based on silica content and alkali ratio and containing less than 4 per cent soda (Na_2O) content.

"The silica number and ratio numbers are to be used in combination. For example: Grade No. 67–51 designates a spar of silica content 66.00 up to 67.99 per cent and with 5 or more parts of potash (K_2O) to 1 part of soda (Na_2O).

Number	*Silica (SiO_2) content in per cent*
65	64.00–65.99
67	66.00–67.99
69	68.00–69.99
71	70.00–71.99
73	72.00–73.99

	Potash (K_2O) soda (Na_2O) ratio
61	6 or more potash to 1 soda
51	5 potash to 1 soda up to 6 potash to 1 soda
41	More than 3 and less than 5 potash to 1 soda
31	3 or less potash to 1 soda

"GROUP 2

"The second group includes the spars used chiefly for glazing purposes which are based on soda content and contain 4 per cent or more soda (Na_2O).

Number	*Soda (Na_2O) content in per cent*
4	4.00–4.99
5	5.00–5.99
6	6.00–6.99
7	7.00–7.99
8	8.00–8.99

"GROUP 3

"The third group includes the spars used for glass-making purposes and are based on silica, alumina, and iron content.

"The numbers are to be used in combination: For example, grade 69–17–X represents a grade of spar of 68.00 to 69.99 per cent silica, 17.00 to 17.99 per cent alumina, and with a maximum of 0.15 per cent Fe_2O_3 content.

Number	*Silica (SiO_2) content*
65	64.00–65.99
67	66.00–67.99
69	68.00–69.99
71	70.00–71.99

	Alumina (Al_2O_3) content in per cent
15	15.00–15.99
16	16.00–16.99
17	17.00–17.99
18	18.00–18.99
19	19.00–19.99

	Iron (Fe_2O_3) content in per cent
X	A maximum of 0.15
XX	A maximum of 0.20
XXX	Above 0.20

"IV. STANDARD METHODS OF TEST

"A. PHYSICAL TEST

"Mesh or fineness.—A 100 g. portion of the dry sample is weighed out to an accuracy of O. l. g. It is then transferred to a number 200 sieve and over a sieve pan which fits closely. The pan shall contain sufficient water to reach within not less than one-fourth inch or more than three-fourths inch from the top of the pan. The sieve and pan shall be vibrated or shaken in such manner that water in the pan is splashed on the screen from below, so as to wash the powder about and cause the material that can pass through the sieve to pass into the pan below. This treatment shall be continued until no appreciable amount is passing through. The contents of the screen are then washed into a pan and thoroughly dried. The dried material is then placed on the coarsest sieve to be used. The finer screens, including the number 200, are placed in order of size under the coarsest, the number 200 being at the bottom. The tier of screens is then shaken until no more than 0.05 of a gram passes any screen after one minute of shaking each time. This point determined by weighing the residue on the coarsest screen, reshaking for a minute until finished, then going to the next size and repeating the process.

·STATE · OF · CALIFORNIA·

"GROUP 1

"The first group includes the commonly accepted ceramic or body grades based on silica content and alkali ratio and containing less than 4 per cent soda (Na_2O) content.

"The silica number and ratio numbers are to be used in combination. For example: Grade No. 67–51 designates a spar of silica content 66.00 up to 67.99 per cent and with 5 or more parts of potash (K_2O) to 1 part of soda (Na_2O).

Number	*Silica (SiO_2) content in per cent*
65	64.00–65.99
67	66.00–67.99
69	68.00–69.99
71	70.00–71.99
73	72.00–73.99

	Potash (K_2O) soda (Na_2O) ratio
61	6 or more potash to 1 soda
51	5 potash to 1 soda up to 6 potash to 1 soda
41	More than 3 and less than 5 potash to 1 soda
31	3 or less potash to 1 soda

"GROUP 2

"The second group includes the spars used chiefly for glazing purposes which are based on soda content and contain 4 per cent or more soda (Na_2O).

Number	*Soda (Na_2O) content in per cent*
4	4.00–4.99
5	5.00–5.99
6	6.00–6.99
7	7.00–7.99
8	8.00–8.99

"GROUP 3

"The third group includes the spars used for glass-making purposes and are based on silica, alumina, and iron content.

"The numbers are to be used in combination: For example, grade 69–17–X represents a grade of spar of 68.00 to 69.99 per cent silica, 17.00 to 17.99 per cent alumina, and with a maximum of 0.15 per cent Fe_2O_3 content.

Number	*Silica (SiO_2) content*
65	64.00–65.99
67	66.00–67.99
69	68.00–69.99
71	70.00–71.99

	Alumina (Al_2O_3) content in per cent
15	15.00–15.99
16	16.00–16.99
17	17.00–17.99
18	18.00–18.99
19	19.00–19.99

	Iron (Fe_2O_3) content in per cent
X	A maximum of 0.15
XX	A maximum of 0.20
XXX	Above 0.20

"IV. STANDARD METHODS OF TEST

"A. PHYSICAL TEST

"*Mesh or fineness.*—A 100 g. portion of the dry sample is weighed out to an accuracy of O. l. g. It is then transferred to a number 200 sieve and over a sieve pan which fits closely. The pan shall contain sufficient water to reach within not less than one-fourth inch or more than three-fourths inch from the top of the pan. The sieve and pan shall be vibrated or shaken in such manner that water in the pan is splashed on the screen from below, so as to wash the powder about and cause the material that can pass through the sieve to pass into the pan below. This treatment shall be continued until no appreciable amount is passing through. The contents of the screen are then washed into a pan and thoroughly dried. The dried material is then placed on the coarsest sieve to be used. The finer screens, including the number 200, are placed in order of size under the coarsest, the number 200 being at the bottom. The tier of screens is then shaken until no more than 0.05 of a gram passes any screen after one minute of shaking each time. This point determined by weighing the residue on the coarsest screen, reshaking for a minute until finished, then going to the next size and repeating the process.

"GROUP 1

"The first group includes the commonly accepted ceramic or body grades based on silica content and alkali ratio and containing less than 4 per cent soda (Na_2O) content.

"The silica number and ratio numbers are to be used in combination. For example: Grade No. 67–51 designates a spar of silica content 66.00 up to 67.99 per cent and with 5 or more parts of potash (K_2O) to 1 part of soda (Na_2O).

Number	*Silica (SiO_2) content in per cent*
65	64.00–65.99
67	66.00–67.99
69	68.00–69.99
71	70.00–71.99
73	72.00–73.99

	Potash (K_2O) soda (Na_2O) ratio
61	6 or more potash to 1 soda
51	5 potash to 1 soda up to 6 potash to 1 soda
41	More than 3 and less than 5 potash to 1 soda
31	3 or less potash to 1 soda

"GROUP 2

"The second group includes the spars used chiefly for glazing purposes which are based on soda content and contain 4 per cent or more soda (Na_2O).

Number	*Soda (Na_2O) content in per cent*
4	4.00–4.99
5	5.00–5.99
6	6.00–6.99
7	7.00–7.99
8	8.00–8.99

"GROUP 3

"The third group includes the spars used for glass-making purposes and are based on silica, alumina, and iron content.

"The numbers are to be used in combination: For example, grade 69–17–X represents a grade of spar of 68.00 to 69.99 per cent silica, 17.00 to 17.99 per cent alumina, and with a maximum of 0.15 per cent Fe_2O_3 content.

Number	*Silica (SiO_2) content*
65	64.00–65.99
67	66.00–67.99
69	68.00–69.99
71	70.00–71.99

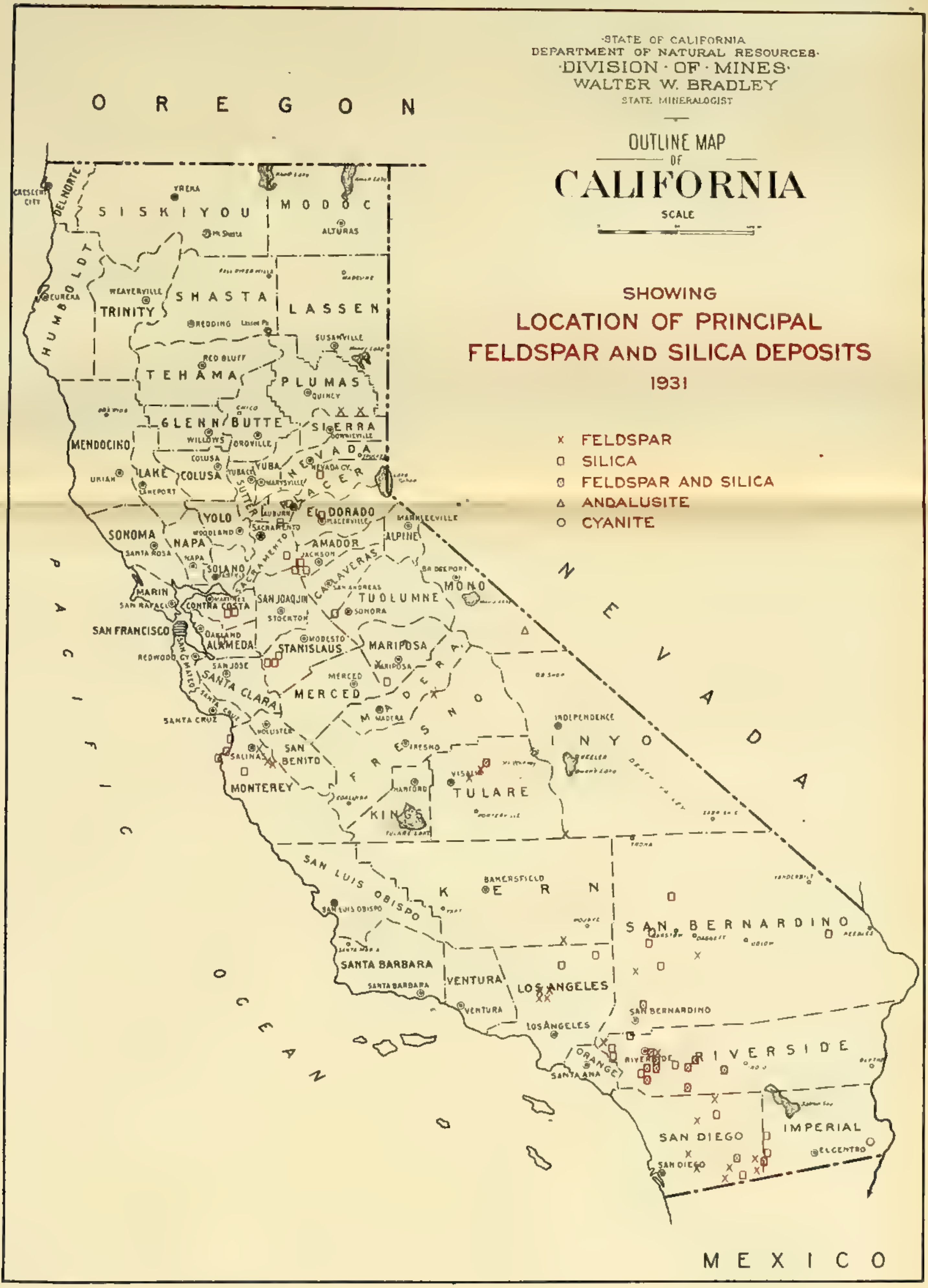
	Alumina (Al_2O_3) content in per cent
15	15.00–15.99
16	16.00–16.99
17	17.00–17.99
18	18.00–18.99
19	19.00–19.99

	Iron (Fe_2O_3) content in per cent
X	A maximum of 0.15
XX	A maximum of 0.20
XXX	Above 0.20

"IV. STANDARD METHODS OF TEST

"A. PHYSICAL TEST

"*Mesh or fineness.*—A 100 g. portion of the dry sample is weighed out to an accuracy of O. l. g. It is then transferred to a number 200 sieve and over a sieve pan which fits closely. The pan shall contain sufficient water to reach within not less than one-fourth inch or more than three-fourths inch from the top of the pan. The sieve and pan shall be vibrated or shaken in such manner that water in the pan is splashed on the screen from below, so as to wash the powder about and cause the material that can pass through the sieve to pass into the pan below. This treatment shall be continued until no appreciable amount is passing through. The contents of the screen are then washed into a pan and thoroughly dried. The dried material is then placed on the coarsest sieve to be used. The finer screens, including the number 200, are placed in order of size under the coarsest, the number 200 being at the bottom. The tier of screens is then shaken until no more than 0.05 of a gram passes any screen after one minute of shaking each time. This point determined by weighing the residue on the coarsest screen, reshaking for a minute until finished, then going to the next size and repeating the process.


STATE OF CALIFORNIA
DEPARTMENT OF NATURAL RESOURCES
DIVISION OF MINES
WALTER W. BRADLEY
STATE MINERALOGIST
OUTLINE MAP OF CALIFORNIA
SCALE
SHOWING
LOCATION OF PRINCIPAL FELDSPAR AND SILICA DEPOSITS
1931
x FELDSPAR
□ SILICA
⊠ FELDSPAR AND SILICA
△ ANDALUSITE
○ CYANITE
OREGON
NEVADA
MEXICO
PACIFIC OCEAN
SISKIYOU
MODOC
DEL NORTE
HUMBOLDT
TRINITY
SHASTA
LASSEN
TEHAMA
PLUMAS
GLENN
BUTTE
SIERRA
MENDOCINO
LAKE
COLUSA
YUBA
NEVADA
PLACER
SUTTER
YOLO
EL DORADO
SONOMA
NAPA
SOLANO
SACRAMENTO
AMADOR
ALPINE
CALAVERAS
MARIN
CONTRA COSTA
SAN JOAQUIN
TUOLUMNE
MONO
SAN FRANCISCO
ALAMEDA
STANISLAUS
MARIPOSA
SAN MATEO
SANTA CLARA
MERCED
MADERA
SANTA CRUZ
SAN BENITO
FRESNO
INYO
MONTEREY
TULARE
KINGS
SAN LUIS OBISPO
KERN
SAN BERNARDINO
SANTA BARBARA
VENTURA
LOS ANGELES
ORANGE
RIVERSIDE
SAN DIEGO
IMPERIAL
YREKA
ALTURAS
WEAVERVILLE
REDDING
SUSANVILLE
RED BLUFF
QUINCY
WILLOWS
OROVILLE
UKIAH
MARYSVILLE
NEVADA CY.
AUBURN
PLACERVILLE
MARKLEEVILLE
WOODLAND
SACRAMENTO
SANTA ROSA
JACKSON
SAN ANDREAS
SAN RAFAEL
STOCKTON
SONORA
OAKLAND
MODESTO
REDWOOD CY.
SAN JOSE
MARIPOSA
MERCED
SANTA CRUZ
HOLLISTER
SALINAS
FRESNO
INDEPENDENCE
VISALIA
HANFORD
BAKERSFIELD
SAN LUIS OBISPO
SANTA BARBARA
VENTURA
LOS ANGELES
SAN BERNARDINO
RIVERSIDE
SANTA ANA
SAN DIEGO
EL CENTRO

"B. CHEMICAL TESTS

"GENERAL

"Feldspar is analyzed for SiO_2, 'R_2O_3' Al_2O_3, Fe_2O_3, CaO, MgO, K_2O, Na_2O, and ignition loss. SiO_2, 'R_2O_3' CaO, MgO, K_2O, and Na_2O are determined in 0.5 g samples. Ignition loss is determined in a 5 g sample. Fe_2O_3 is determined potentiometrically in a 10 g sample, and the result is subtracted from the percentage of 'R_2O_3' to give Al_2O_3. The result for the latter will of course include constituents such as TiO_2, ZrO_2, P_2O_5 and the like.

"Accurate results in the analysis of feldspar are not easy to obtain, especially in the cases of SiO_2 and 'R_2O_3'. Attention must be paid to all details. Variations in check analyses should be within the following limits: SiO_2, 0.2 per cent; 'R_2O_3,' 0.2 per cent; CaO, 0.05 per cent; MgO, 0.05 per cent; K_2O plus Na_2O, 0.2 per cent.

"Analyses should be repeated if the summation does not fall between 99.75 and 100.5 per cent.

"Analyses of potash feldspars should be checked against the Bureau of Standards standard sample No. 70, and analyses of soda feldspars should be checked against the Bureau of Standards standard sample No. 99.

"All results should be corrected by blank runs on reagents and factors should be calculated from the current International Table of Atomic Weights."

FELDSPAR AND SILICA

Californian Deposits*

Amador County.

Samples of orthoclase feldspar of fair quality have been received in the laboratory of the Division of Mines, stated to have come from Amador County, but the exact locality is as yet unverified.

Fresno County.

Childers Feldspar and Silica Deposit. It is situated in Sec. 23, T. 9 S., R. 22 E., M. D. M., 4 miles northwest of Auberry, the terminus of the S. & E. Railroad and 20 miles northeast of Friant, a station on the Southern Pacific Railroad. Elevation 3000′. Holdings comprise 8 claims, totaling 160 acres. Owner, W. H. Childers, of Auberry, California. Under lease to G. A. Scott, of San Francisco.

A series of parallel pegmatite veins occur in the granite, strike N. 40° W. Along this system of veins occur massive outcrops of feldspar and silica, widths varying from 10′ to 50′. The different outcrops have been prospected by a number of opencuts. There are six opencuts on Point View Claim No. 1. These cuts expose from 2′ to 6′ of feldspar which is a good quality of orthoclase, white in color. Three men employed on development.

Bibl: State Mineralogist's Report XXV, p. 311.

Harrison Stock Farm Deposit at Clovis, California, is within one mile of the railroad. C. T. Biddle, 2059 Market Street, San Francisco, has done a little surface prospecting on a large outcrop which is otherwise undeveloped. Owners, George Hawkins et al, 2059 Market Street, San Francisco.

Inyo County.

Nine-Mile Canyon Feldspar Deposit. It comprises three claims, situated in T. 24 S., R. 37 E., S. B. B., 5 miles west of Linnie, a siding on Owens Valley branch of the Southern Pacific Railroad. Elevation 4000′. Owner, E. G. Washmuth, Inyokern, California.

* Data on deposits located in northern California were supplied by C. A. Logan, District Engineer, Sacramento, and by C. McK. Laizure, District Engineer, San Francisco.

Two massive outcrops of silica and feldspar occur in the granite, on a ridge west of Nine-Mile Canyon. The lower outcrop is about 250′ in elevation above the floor of the canyon. This outcrop is about 40′ in width by 100′ in length. It is developed by a crosscut tunnel driven south 40′ in granite. In the face of this tunnel there is exposed 6′ of feldspar and 8′ of silica. A raise was put up on this feldspar to the surface a distance of 20′, then material mined from a glory hole 15′ in length by 20′ in width. The feldspar is brown to pink in color and shows the presence of silica, which would require careful sorting. The outcrop strikes northeast. About 200′ southwest of the workings is an outcrop of silica that dips with the slope of the hill and shows indications of feldspar.

About 250′ south of the lower workings and about 300′ in elevation above these workings, is a massive outcrop of feldspar and silica. This outcrop is 150′ wide by 200′ in length. On the north side of this outcrop, an open cut has been made which exposes 8′ of solid feldspar. The feldspar is brown to pink in color and appears to be of good quality. The surface outcrop strikes northeast and is made up of segregations of feldspar and silica. One 50-ton car of feldspar was shipped to Los Angeles Chemical Company in 1930.

Analysis

SiO_2	Al_2O_3	*Fe*	*CaO*	*Mg*	*K*	*Na*	*Loss*
63.82	18.54	0.11	.00	0.61	13.33	1.35	.04

Equipment consists of 4′x6′ Gardner compressor, driven by gas engine; incline tram line 500′ in length; and 50-ton storage bin. Idle.

Kern County.

Rosamond Feldspar and Silica Deposit. It comprises 20 acres situated in SW¼ of Sec. 6, T. 9 N., R. 12 W., S. B. M., 3 miles northwest of Rosamond. Owner, N. W. Sweetzer, Rosamond, California.

The feldspar, which is orthoclase, pink to brown in color, occurs in masses in quartz and is also segregated on each wall between granite and silica. The deposit consists of a bold outcrop of silica and feldspar in granite, along a pegmatite dike which strikes east and dips 70° south. The outcrop of silica is about 300′ from north to south and 200′ from east to west. In an opencut north of the shaft there is exposed 4′ to 6′ of brown to pink feldspar. The main feldspar orebody that has been developed has granite as a footwall, with hanging wall made up of a mixture of feldspar and silica.

Development: A vertical shaft has been sunk to a depth of 75′. At 40′ the shaft passed through a lens of feldspar 6′ to 10′ in thickness, which dips to the south. The bottom of the shaft is in the footwall granite. On 70-foot level a drift has been driven west 70′ following the footwall. This drift exposes several lenticular masses of feldspar and silica, the face of the drift being in feldspar. A crosscut has been driven south from the shaft a distance of 90′. This crosscut exposes lenses of brown feldspar, varying from 6′ to 20′ in thickness. An incline raise has been put through to surface from this crosscut, which passes through a lens of feldspar 20′ in thickness. The feldspar is orthoclase, brown to pink in color, containing a small amount of clay

on cleavage planes; also some crystals of silica, with occasional small bunches of muscovite in the mass.

The ore as hoisted from the mine contains quite a percentage of moisture. The mine run of ore is trammed in cars to a drying platform, on which it is spread out for drying. It requires twenty-four hours to thoroughly dry the material. The ore from the drying platform goes to a revolving screen, where it is screened to 20-mesh; the oversize goes to a picking belt where silica is sorted out; then conveyed to 50-ton storage bin; the minus 20-mesh product to waste dump.

Equipment consists of 6-h.p. Fairbanks-Morse hoist; 6″x8″ Gardner compressor; air drills and cars.

Production amounts to two 50-ton cars of feldspar per month which is shipped to the American Encaustic Tiling Company, Los Angeles. Three men employed.

Average sample of 180 tons: SiO_2 69.85; Al_2O_3 16.34; Fe_2O_3 0.12; MgO 0.10; CaO 1.83; K_2O 9.13; Na_2O 2.31; TiO_2 trace; Cl none; SO_2 none; total 99.68.

Bibl: State Mineralogist's Report XXV, p. 65.

Los Angeles County.

There is an extensive belt of labradorite, lime-soda feldspar, containing a high-aluminum content that extends east from Lang on both sides of Soledad Canyon to Ravenna, a distance of about 12 miles. Labradorite is a constituent of the rocks of Mount Gleason. This alumina-silicate rock probably could be used in the manufacture of high-grade refractory products, such as porcelain, pottery, electric insulators, spark plugs, sanitary ware for plumbing and cleanser compounds.

The following is an analysis of the alumina-silicate rock from samples taken near Lang, made by C. W. Hill Company, of Los Angeles:

Silica	58.10%
Alumina	28.27
Ferric oxide	1.03
Lime	8.60
Magnesia	0.54
Potash	1.60
Soda	0.82
Moisture	0.10
Loss in ignition	0.55
Total	99.61%

Caliproducts Company's Deposit. The deposit is located in Sec. 15, T. 4 N., R. 13 W., S. B. M., one mile south of Ravenna, a station on Southern Pacific Railroad. Elevation 2650′. Holdings comprise 200 acres. Owner, Lenardo Ruiz, Acton, California. Under option to the Caliproducts Company; Ralph C. McInery, president, Los Angeles.

It has been estimated that there are millions of tons of soda-lime feldspar rock exposed on this property.

Development consists of several tunnels and opencuts. The material was mined through a tunnel with laterals driven east and west along the strike of the labradorite. The material is trammed in one-ton cars to 100-ton grinding plant, where it is crushed, screened,

reground and rescreened into a finished product for the local market at Los Angeles. The plant was operated in 1925 and some material shipped to glass and pottery manufacturers. The material was not satisfactory due to the iron content, which was over 1%. Owing to limitations in the supply of high-grade potash feldspar in California, there is a possibility that these deposits may be of commercial importance in the future. Idle.

Bibl: State Mineralogist's Report XXIII, pp. 322–323.

Chicago-Pacific Deposit. This deposit is located in a range of hills north and south of Soledad Canyon, in Secs. 8, 9, 15, 16 and 17, T. 4 N., R. 14 W., S. B. M., 11 miles east of Saugus and one-quarter of a mile north of Lang, a station on the Southern Pacific Railroad. Holdings comprise 13 claims. Owners, J. P. Monahan, J. G. Krown, Los Angeles.

100-ton mill. Caliproducts Company, Ravenna, Los Angeles County.

It is a massive deposit of labradorite (soda-lime feldspar), containing a high aluminum content, which, according to analysis, should probably be satisfactory for the manufacture of refractory products. The low iron content suggests its use for high-grade white Portland cement and it also might be used for a paint filler and for cleanser compounds.

The general strike of the formation is east and it can be followed from Lang to Alpine Siding, on the Southern Pacific Railroad, a distance of two miles. It is about two miles in width and occurs in contact with schist, which lies to the south of the labradorite. Idle.

Bibl: State Mineralogist's Report XXIII, pp. 323–324.

Duncan Feldspar Deposit. It is located in Secs. 14 and 15, T. 4 N., R. 13 W., S. B. M., one mile south of Ravenna, a station on the Southern Pacific Railroad. Elevation 2500′. Owner, Harry Duncan, Los Angeles. Holdings comprise 160 acres of patented land.

An extensive deposit of labradorite (soda-lime feldspar) covers this area. It is reported that in 1915, 2000 tons of this material was shipped from the deposit to Los Angeles for manufacture of electrical insulators. Idle.

Bibl: State Mineralogist's Report XXIII, p. 324.

Gates Chemical Company's Deposit. This deposit of labradorite (soda-lime feldspar) is located at Alpine Siding, on the Southern Pacific Railroad, in Soledad Canyon, 2 miles east of Lang. Holdings comprise 7 claims, in Sec. 15, T. 4 N., R. 14 W., S. B. M. Owner, Gates Chemical Company; E. S. Gates, president; M. L. Gates, secretary. Offices, Denver, Colorado.

This is a large deposit of alumina-silicate rock, white in color and appears to have a low iron content.

Development consists of a quarry 150′ in length with a bank 20′ in height, which is located just south of Alpine Siding. During 1917–1918 the material was shipped to the company's plant at Pacoima, where it was ground and screened and a product produced known as Gates' Cleanser. Idle.

Bibl: State Mineralogist's Report XXIII, p. 324.

Stanley Deposit. It is a large deposit of labradorite (soda-lime feldspar) situated in Secs. 26 and 28, T. 4 N., R. 14 W., S. B. M., 4 miles southeast of Lang. Elevation 3000′. Holdings comprise 160 acres. Owner, George Stanley, Los Angles. Idle.

Bibl: State Mineralogist's Report XXIII, p. 324.

Silica Mining and Feldspar Deposit. This deposit of feldspar and silica is located one-half mile northeast of Acton, a station on the Southern Pacific Railroad. Elevation 3200′. Holdings comprise two claims. Owner, *Silica Mining and Products Company,* Los Angeles; S. M. Clayton, president.

A vein of feldspar and silica occurs in granite. It strikes northeast and dips 60° NW, and has an average width of 25′.

Workings consist of an opencut on incline of the vein for a distance of 25′. The silica is on the footwall of the vein, with feldspar on the hanging wall. The quartz is clear white, containing occasional streaks of hematite and bunches of muscovite. The feldspar is a pink orthoclase of good quality.

Shipments of feldspar and silica were made from the deposit in 1926. Idle.

Madera County.

There is in the mineral exhibit of the division of mines, a specimen of good-looking orthoclase feldspar, white in color, from near Hildreth in Madera County; but data appear to be lacking as to the exact locality and extent of the deposit.

Mariposa County.

Hamilton Feldspar Deposit: This deposit is on the old Joseph Carmichael Ranch, in Sec. 30, T. 5 S., R. 17 E., now owned by Matthew Hamilton, Stockton, California. It is located 7 miles easterly from Hornitos or 15 miles from Yosemite Valley Railroad at Merced Falls.

Elevation 1350′. Bear and Corbett creeks flow through the property which comprises 485 acres of patented land.

There are three known ledges and several massive deposits reported. The outcrop varies from a few feet to over 300′ in width and can be traced on the surface for nearly a mile. Determination of samples from the deposit show it to be orthoclase (potash) feldspar, with a small amount of iron present. Undeveloped.

Bibl: State Mineralogist's Report XXIV, p. 146.

Monterey County.

Bardin Feldspar Deposit. A deposit of feldspar occurs on the property owned by H. Bardin, Salinas, California. It is situated 7 miles east of Salinas. Undeveloped.

Bibl: State Mineralogist's Report XVII, p. 156.

Jennie Tonge, Soledad, California, is reported to have an undeveloped deposit on her property. It is on the same belt as the Jens quarry.

Jens Feldspar Deposit. This deposit is situated in Sec. 34, T. 15 S., R. 5 E., about 5 miles east of Chualar. Owner, J. C. Jens, 636 West Adams Street, Los Angeles.

A massive outcrop of feldspar and silica occurs on contact of granite and limestone. The outcrop varies in width from 20′ to 150′ and can be traced along its strike for several thousand feet. A large tonnage of feldspar was shipped in 1920 by George W. Elder, of San Francisco. Idle.

Bibl: State Mineralogist's Reports XV, p. 601; XVII, p. 156; XXI, p. 37.

Johnson Bros. Feldspar Deposit. This deposit is located in Chualar Canyon, 5 miles east of Chualar and about one-half mile from the Jens Feldspar Deposit. Owners, Johnson Bros., Chualar, California.

A massive outcrop of feldspar and silica occurs on the Johnson ranch and can be traced along its outcrop for considerable distance. It is an orthoclase feldspar and is said to be of good commercial grade. Undeveloped.

Bibl: State Mineralogist's Report XXI, p. 37.

Plumas County.

C. C. Rumsey, Chilcoot, California, reports he has a large deposit of high-grade feldspar near Chilcoot. No detailed information available at this time.

There is in the museum of the Division of Mines a specimen of pink-colored orthoclase of good grade received from G. E. Lundy of San Francisco, and stated to have come from near Portola in Plumas County, but no data are at hand as to the probable extent of the deposit.

Riverside County.

Alert Ranch Deposit, formerly known as Mountain View Ranch. This deposit is on a tract which consists of 160 acres of patented land, in Sec. 26, T. 4 S., R. 2 E., S.B.M., 4 miles south of Lakeview on the

north slope of the Lakeview Hills. Elevation 2000′. Owner, Fred Alert, Lakeview, California.

Boulders of feldspar are found in massive outcrops of quartz which occur in a series of parallel pegmatite dikes in granite. It is doubtful if there is sufficient feldspar to be of commercial importance, although there is a possibility of mining silica with a low iron content.

American Encaustic Tiling Company, 2030 East 52 Street, Los Angeles, is working deposits of feldspar and silica which are located on an 800-acre tract, under lease from the *California Land and Mineral Company.* The property comprises Sec. 4, T. 7 S., R. 3 W., S. B. M., and the northwest corner of the Temecula Rancho, being about 3 miles from the town of Murrietta.

The deposits occur in roughly-parallel zones in the granite. The potash feldspar and quartz of the pegmatite are segregated into bands which vary in thickness from 1′ to 6′ near the granite contact. The center of the deposit is largely quartz, although boulders of feldspar are also encountered. The total thickness of feldspar and quartz at one point is 80′ as shown in an opencut from which most of the shipments have been made. Here an open pit 70′ deep by 60′ wide and 120′ long has been excavated. From the 60-foot level of this pit crosscuts were driven north a distance of 40′ to the north wall of the deposit. Raises were put up to the capping and the feldspar and quartz were removed by top slicing, without caving the surface. These slices were 8′ thick. The stoping was carried beyond the east end of the open pit so that the developed length of this lens is 250′. It is estimated that some 30,000 to 50,000 tons of material are now developed at this place.

Material is hoisted from this pit in $\frac{3}{4}$-ton cars, on a cage by a 15-h.p. gas-engine hoist. It is dumped into a $3\frac{1}{2}$′ trommel, set on a very slight inclination. This machine is used as a washer, a stream of water being passed through with the rock. The two products from the trommel are conveyed by a short belt to a two-compartment, 40-ton bin, which discharges into trucks below.

On the north side of a small hill, one-half mile west of the above-described pit, a crosscut is being driven. This crosscut passed through 40′ of granite into a lens of feldspar and quartz which it has penetrated for a distance of 30′, the face showing the same material. The top three feet of this deposit is feldspar. Numerous small opencuts are scattered over the property. One of these is reported to have produced 2000 tons of feldspar from a lens which was free from quartz.

At present they are shipping some 250 tons of silica per month, with practically no spar. Shipments of spar in the past from the property are reported to have aggregated about 50,000 tons.

Three men are employed.

Bibl: State Mineralogist's Report XXV, pp. 502–503.

Brown Ranch Feldspar Deposit, consisting of 4 claims, is in the SE$\frac{1}{4}$, Sec. 28, T. 4 S., R. 2 W., S.B.M. It is on the northeast slope of the Lakeview Hills, 5 miles south of Lakeview. Elevation 2000′. Owner, A. M. Brown, Lakeview, California.

Massive outcrops of silica occur along a pegmatite dike in granite; strike northwest. Segregations of feldspar occur in this outcrop,

which is about 100′ wide and is traceable for approximately 1500′. Opencuts along the outcrop have exposed feldspar bands in widths varying from 1′ to 2′. Some silica was mined and shipped from the deposit several years ago. The silica is clear white, with low iron content.

Coahuila Brave Deposit. C. E. Williamson, 1107 West 56th Street, Los Angeles, has deposits of feldspar and silica on 5 claims in the Coahuila Mountains, 35 miles east of Temecula. Elevation of workings 5500′.

It is reported that there are seven roughly-parallel pegmatite dikes in granite, having an average width of 10′. These zones have northeasterly strikes and dip at an angle of approximately 60° to the southeast. The feldspar occurs in masses enclosed by the clear, vitreous quartz.

Operations have been carried on in an opencut 40′ deep, 10′ wide and 75′ long, near the top of the mountain. The sorted feldspar is taken down the mountain by a low-geared truck and dumped into a small bin; thence to the railroad at Temecula in standard-geared trucks.

This deposit was not visited. The above information was given by Mr. Williamson.

Bibl: State Mineralogist's Report XXV, pp. 503–504.

Ensley-Spaulding Deposit. Oliver P. Ensley and H. H. Spaulding, Hemet, California, are reported to have shipped 4 cars from a deposit of feldspar and silica which is located 7 miles southwest of Hemet and 4 miles from Egan.

It consisted of several small lenses in granite, the feldspar having a thickness of one foot. This pinched out at a depth of 20′.

Bibl: State Mineralogist's Report XXV, p. 504.

K. & K. Ranch Deposit is on the E. ½ of Sec. 3, T. 5 S., R. 2 W., 5 miles west of San Jacinto on the Santa Fe Railroad. It is also on the Perris-Hemet highway. Elevation 2000′. Owner, K. & K. Corporation, Ltd.; S. J. Cass, president, Quinby Building, Los Angeles. Was under lease to J. Von Gal-Scale, of Los Angeles.

Outcrops of feldspar and silica occur in the granite, on the east slope of a small, rounded hill. The strike is east, the dip to the north, at a low angle. The outcrop is 150′ long by about 50′ in width. The feldspar occurs as irregular masses associated with silica. An opencut on the north slope of the hill 10′ in length, exposes 2′ of feldspar and 4′ of clear, white silica. There is another opencut about 50′ east, 20′ long by 10′ deep and 15′ wide, from which a shipment of 50 tons was made.

La Borde Deposit. It is in Sec. 28, T. 4 S., R. 2 W., S.B.M., 4 miles southeast of Nuevo, on the west slope of the Lakeview Mountains. Owners, La Borde Bros., Perris, California.

About 2000 tons of feldspar was shipped from this deposit to the C. W. Hill Chemical Company, of Los Angeles.

The spar occurred as irregular lenses or masses in a pegmatite dike, in granite. Idle.

Bibl: State Mineralogist's Report XXV, p. 505.

Lang Deposit is in the NE. ¼ of SE. ¼ of Sec. 12, T. 8 S., R. 1 E., also fraction of NW. ¼ of SW. ¼ of Sec. 7, T. 8 S., R. 2 E., S.B.M. It is 4 miles east of Aguanga and about 27 miles east of Temecula and comprises 84.7 acres. Elevation 3600′. Owner, J. S. Lang, Aguanga, California.

Silica and feldspar, occurring in granite, outcrop for a distance of 700′. Strike is N. 20° W., dip 60° W. Exposures on three small knolls, width about 20′. The feldspar is of good grade, containing from 10 to 11% K_2O. Silica is also of good commercial quality.

Development consists of an opencut which is 20′ wide, about 50′ in length and 10′ deep. On the west of the cut, there are 3′ of quartz, then 5′ of feldspar exposed, followed by 10′ of mixed quartz and feldspar. Continuity and size of outcrop would indicate that a considerable tonnage could be developed here. Idle.

Bibl: State Mineralogist's Report XXV, p. 505.

Last Chance Feldspar and Silica Deposit, comprising 6 patented claims, is in Sec. 2, T. 6 S., R. 1 E., S.B.M., 5 miles southeast of Hemet. It is on a ridge southwest of Bautiste Creek, at an elevation of about 2300′. Owners, E. W. Green, San Jacinto, and James Jones, of Los Angeles.

Here, a series of pegmatite dikes occur in the granite. Strike N. 40° W., dip 50° to 70° NE. In this pegmatite there are massive outcrops of silica, varying in width from 20′ to 200′ and from 200′ to 1000′ in length. Segregations of feldspar from 12″ to 2′ wide occur along these outcrops. In several places there appears to be a possibility of developing a tonnage of high-grade feldspar.

It would be necessary to build about one mile of road from Bautiste Creek to the deposits.

Littlejohn Deposit. This property, consisting of 2 claims, is in T. 6 S., R. 2 E., one mile southwest of Bautiste Canyon and about 11 miles by road east of Hemet. Owner, E. S. Littlejohn, 1333 South Hill Street, Los Angeles.

Segregations of silica and feldspar occur in a series of pegmatite dikes in the granite. The strike of the dikes is N. 20° W. and dip steeply to the west. The outcrop of the principal deposit forms the top of a peak and is visible for some distance. It is about 75′ long and from 35′ to 40′ wide.

Where exposed by an opencut, the silica is clear and apparently free from iron. The feldspar is not yet exposed in the cut but outcrops just above, showing a width of about 6′. Considerable muscovite is encountered at the contact of the silica and the walls. There are several parallel pegmatite dikes in the immediate vicinity and it is probable that, in the aggregate, a good tonnage of both spar and silica could be developed. It would be necessary to build about one mile of road to reach the foot of the peak mentioned. Idle.

Machado Deposit. M. Machado, Temecula, California, has deposits of feldspar and silica, which are located in Sec. 9, T. 5 S., R. 2 W., S.B.M., 3 miles north of Winchester. The tract consists of 480 acres, 160 acres in eight mining claims and 320 acres under lease from W. J. Nierdorf, of Winchester, California. This property is in Rattlesnake

Canyon and the deposits have been opened in the hills on each side of the canyon.

Feldspar occurs in masses enclosed by the quartz, in pegmatite dikes in granite. Strike is N. 40° E. and they dip at low angles to the northwest. Width varies up to 30′.

There are numerous opencuts and trenches on the property from which it is reported that 60 cars have been shipped to the American Encaustic Tiling Company, in Los Angeles. Idle.

Bibl: State Mineralogist's Report XXV, pp. 505–506.

Morgan Ranch Deposit. This property, consisting of 300 acres, is in Sec. 28, T. 4 S., R. 2 W., S.B.M., on the northwest slope of Lakeview Hills, 4 miles south of the town of Lakeview. Elevation 2000′. Owner, John Morgan, of Los Angeles.

A series of silica lenses outcrop in parallel pegmatite dikes, which strike northwest. Segregations of feldspar occur in these outcrops. Undeveloped.

Patterson Ranch Feldspar and Silica Deposit. This property consists of 640 acres, being Sec. 29, T. 4 S., R. 2 W., S.B.M. It is 7 miles south of Lakeview and 8 miles northwest of Winchester, on the northeast slope of the Lakeview Hills at an elevation of 2000′. Owner, J. Neil Patterson, Pasadena, California. Under lease to C. E. Woodruff and James D. Gray, Long Beach, California.

A series of parallel outcrops of silica, containing segregations of feldspar, occur along pegmatite dikes in granite. The general strike is N. 40° W., dip 60° NW. The outcrops are 20′ to 30′ in width and can be traced for a distance of about 200′.

Development consists of a tunnel driven some 40′ below a bold outcrop of more or less intermixed silica and feldspar. This tunnel was driven southeasterly 50′, where it terminates in a glory hole 50′ long by 15′ in width. Exposed in these workings are 6′ to 8′ of feldspar. On the tunnel level the feldspar contains black tourmaline, often bunched into radiating groups. At a higher elevation on the south end of the glory hole are exposed 6′ to 8′ of clear, white feldspar and the conditions appear favorable to the development of a considerable tonnage of commercial spar.

Equipment consists of air compressor and jackhammers. Three men employed.

Perris Mining Company, Route 1, Box 33, Romoland, California, formerly worked a feldspar and silica deposit which is in Sec. 16, T. 6 S., R. 3 W., 10 miles south of Perris. It is at an elevation of 1400′.

The deposit is a segregation in granite, having a strike of S. 70° W. and dip 42° to the southeast at the surface. The feldspar occurs in masses enclosed by the quartz. It is reported that some lenses have been encountered which were 20′ thick.

Development consists of an incline shaft which bears S. 15° E., has an inclination of 42° and a length along the incline which is reported to be 150′. Fifty feet east of this incline is a vertical shaft with a reported depth of 80′. The two are connected on the 50-foot level and the ground has been stoped from this level practically to the surface. On the 75-foot level in the inclined shaft, a drift has been driven to the northwest a distance of about 50′. At the end of an

opencut, 50′ east of the vertical shaft, is the portal of a tunnel approximately 15′ below the surface. It is reported that this tunnel was driven in an easterly direction for a distance of 500′. No deposits of commercial value were encountered in the tunnel. As all of these workings were full of water at the time of our visit, they could not be inspected.

At the incline shaft an air hoist operates a ½-ton skip which dumps into a 10-ton bin. At the vertical shaft there is a 6-h.p. gas-engine hoist. The skip dumps into a 20-ton bin. The two bins are connected by a trestle.

The mill consists of 6″ x 9″ jaw crusher, followed by 12″ rolls. Material is then elevated to a 3-deck vibrating screen, discharging to a 4-compartment bin. The material is then ground by a pebble mill. Two dust collectors and two air separaters complete the equipment. A 25-h.p. gas engine is so placed that it may be used to drive either an 8″ x 6″ air compressor or the main shaft of the mill.

The product was used for chicken grit and in the manufacture of porcelain and tile. Idle.

Bibl: State Mineralogist's Report XXV, p. 506.

Riverside Portland Cement Company formerly operated a deposit which is in the E. ½ of Sec. 29, T. 4 S., R. 2 W., S. B. M. It is 3 miles south of Lakeview on the north slope of the Lakeview Mountains.

The feldspar occurs in pegmatite dikes in granite. Potash content varied from 10 to 12%. Product was shipped to the company's cement plant near Riverside.

Idle and presumably exhausted.

Bibl: State Mineralogist's Report XXV, p. 506.

Stone Deposit. C. P. Stone, 845 South Hill Street, Los Angeles, shipped feldspar and silica from a deposit which is seven miles west of Riverside, in the Jurupa Mountains. Elevation 1300′.

The deposits occur as pegmatite dikes in granite. These dikes vary in width from 5′ to 25′. They are roughly parallel, having a strike of N. 45° W. and dipping steeply to the northeast. They are separated by from 30′ to 50′ of granite. The feldspar occurs in masses, completely enclosed by the clear, vitreous quartz.

A road has been built to the top of a hill where a deposit has been opened by a trench 10′ deep by 80′ long. The zone at this point has an average width of 6′. This trench and some three or four opencuts near the base of the hill, constitute all of the development work to date. Idle.

Bibl: State Mineralogist's Report XXV, p. 507.

Tully Deposit. It is 3 miles south of Lakeview in Sec. 32, T. 4 S., R. 2 W., S. B. M., on the north slope of the Lakeview Mountains. Owner, W. M. Tully, Nuevo, California.

Large boulders of feldspar occur in a pegmatite dike in granite. The deposits are very irregular and appear to lie almost flat.

The largest deposit yielded about 2500 tons. Idle.

Bibl: State Mineralogist's Report XXV, p. 507.

Weir Ranch Feldspar and Silica Deposit. This patented property, consisting of 320 acres, is in Sec. 29, T. 4 S., R. 2 W., S. B. M., 4 miles south of Lakeview, on the northwest slope of the Lakeview Hills. Elevation 2000′. Owner, A. C. Weir, Los Angeles.

Small segregations of feldspar occur in massive silica outcrops along a series of parallel pegmatite dikes in granite. The occurrences of feldspar are limited in extent, too small to be of commercial importance.

Deposits were prospected with a series of opencuts by the Riverside Portland Cement Company and some feldspar was mined in 1917 for its potash content, which, it is reported, varies from 11 to 15%.

San Bernardino County.

Clement and Blackburn Feldspar Deposit. The deposit is situated 1½ miles south of Oro Grande. Seven claims have been filed on the deposit. Owner, Mrs. Ada Clement, Pleasanton, California.

Pegmatite dikes containing orthoclase feldspar occur in the granite. The dikes are said to be 3′ to 10′ wide, strike east and run the full length of the claims. The feldspar is said to contain 11% K_2O. Idle.

Bibl: State Mineralogist's Report XVII, p. 342.

J. H. Sloan, Barstow, California, owns a deposit 3½ miles north of Hinkley, a station on the Santa Fe Railroad. Idle.

Bibl: State Mineralogist's Reports XV, pp. 862–863; XVII, p. 342.

Keystone and Lucky Jim Deposit comprises 8 claims in the San Bernardino Mountains, near the top on the southwest slope. They are in Secs. 20 and 29 (?), T. 2 N., R. 3 W., S. B. M., about one mile southwest of Arrowhead Lake and some 23 miles by road from the city of San Bernardino. Elevation about 5300′ to 5500′. Owners, C. E. Lillibridge and E. R. E. Nonhof, Corona, California.

The deposits occur as more or less distinctly-banded segregations of feldspar, quartz and mica in pegmatite dikes in granite. Strike is generally north and the dip is to the west, varying from 30° to vertical. From the numerous, though at times somewhat indistinct outcrops, it is probable that in the aggregate, a considerable tonnage of feldspar is here available.

Development consists of many shallow trenches and small opencuts in addition to two principal working places. One of these is on Lucky Jim No. 1 claim, and consists of an opencut 35′ long, having a face some 25′ in height. From this face a flatly-inclined raise has been driven a distance of 15′. Some 30′ of this cut shows feldspar with inclusions of quartz masses and vice versa. It is overlain by a fine-grained pegmatite.

The other principal opening is on the Lucky Jim No. 4 claim and consists of a crosscut tunnel which encountered the pegmatite some 15′ from its face. It shows about 8′ of banded quartz and feldspar, the feldspar at this point predominating.

Some shipments of both feldspar and mica have been made from this property. Work is now held up pending final action of the U. S.

District Court on a temporary injunction which was obtained by the Forestry Service.

Bibl: State Mineralogist's Report XXII, p. 303.

In the museum of the State Division of Mines, there is a specimen of orthoclase feldspar from near *Vanderbilt* in eastern San Bernardino County, but no details are at hand relative to the exact locality nor quantity available.

San Diego County.

Carlsbad Group, consisting of 5 claims and a 5-acre millsite, is located in Secs. 23, 26 and 27, T. 9 S., R. 4 E., about 14 miles northeast of Warner Hot Springs. Elevation 4500′ to 5000′. Owner, W. F. Wheeler, P. O. Box 555, San Bernardino, Calfiornia.

While these claims are at present being worked for the mica alone, the quantity of good feldspar exposed in the present openings and the numerous outcrops on these claims and in the immediate vicinity would lead to the conclusion that in the aggregate, a large tonnage will be available here, when transportation facilities are such as to make its extraction commercially profitable.

Open cut on Carlsbad Feldspar and Silica Deposit, 14 miles northeast of Warner Hot Springs, San Diego County.

At present the property is inaccessible except by trail. The old road along Coyote Creek from Temecula would have to be repaired and about two miles of new road built. This would make about a 35-mile haul to the railroad at Temecula.

Dehesa Cornwall Stone Deposit is an extensive one located in Sec. 27, T. 16 S., R. 1 E., S. B. M., on the north slope of McGinty Mountain, southwest of Dehesa. The *American Encaustic Tiling Company,* Los Angeles, mines and ships this rock to its plant at Los Angeles.

The material mined is a feldspathic rock which resembles orthoclase but it is much lower in potash. It is called 'Cornwall Stone,' due to its similarity to rock mined at Duroc, Cornwall, England. The product is hauled by motor truck to El Cajon, a station on the Cuyamaca

branch of the San Diego and Arizona Railroad, a distance of seven miles.

Analysis by Company's Chemist

Silica	77.68%
Alumina	15.97
Lime	2.80
Iron	0.13
Manganese	0.72
Alkalies	2.04
Total	99.34%

Two men are employed.

Bibl: State Mineralogist's Report XXI, p. 358.

Dos Cabezas Deposits are located in Sec. 22, T. 16 S., R. 8 E., S. B. M., one mile north of Dos Cabezas Siding on the San Diego and Arizona Railroad. Owners are M. C. and M. A. Turner and associates, of San Diego, California.

Exposures of feldspar occur here at various points along pegmatite dikes in the granite. These spar deposits are undeveloped but the possibilities look favorable for the development of tonnage, as the outcrops are numerous and extensive. At one place an opencut has developed 14′ of spar which is of good quality and unusually free from impurities such as black mica, hornblende and iron.

Bibl: State Mineralogist's Report XXI, p. 359.

Feldspar Deposit, Flynt Silica and Spar Company, Boulevard, San Diego County.

Flynt Silica and Spar Company's deposit is 8 miles north of White Oak Spring. Owner, Flynt Silica and Spar Company, 1081 Richmond Street, Los Angeles.

Massive outcrops of silica and feldspar occur along pegmatite dikes in granite. General strike about N. 20° W., dip to west at 40°.

Deposit has been developed by opencut 50′ long by 25′ wide, with a depth of about 30′. About 50′ below the floor of this cut, a crosscut tunnel was driven 120′ to the deposit, with drifts some 140′ each north and south. There is a stope in the south drift about 35′ long, 10′ wide

and 40′ high. A raise from the top of the stope connects with the opencut above. The material stoped consisted of feldspar with inclusion of quartz boulders.

Analysis

SiO_2	62.80%
Al_2O_3	22.10
Fe	0.10
CaO	0.30
Mg	Trace
K	11.04
Na	2.70
Loss	0.55
Total	99.59%

Equipment consists of 110-cu. ft. Rix compressor; blacksmith shop; and two loading bins, one at the opencut, the other at the portal of the tunnel.

Six to ten men employed when operating. Idle at time of visit.

Lakeside Deposit is in Sec. 35, T. 15 S., R. 1 E., S. B. M., 5 miles east of Lakeside. Owners, Hardesty and Powers, San Diego, California.

The deposit is developed by opencuts and shows 6′ of spar associated with silica.

It occurs along a pegmatite dike in the granite and the feldspar outcrops at a number of points within a distance of one mile along its general strike. The quality of spar is said to be good, with a high potash content. A considerable tonnage has been shipped.

Bibl: State Mineralogist's Report XXI, p. 359.

Langer Deposit comprises one claim in Sec. 25, T. 11 S., R. 1 W., S. B. M.

Segregations of feldspar and silica in a pegmatite dike in granite outcrop at intervals, throughout a length of about 1000′. After the shipment of a few tons in 1928 the deposit was abandoned as it was found that the silica and feldspar were so intimately mixed that sorting was impractical.

Leonard and Leck, of Escondido, California, have done some work on a deposit on the Escondido-Ramona highway. No commercial spar was encountered.

Marden Deposit is located 5 miles northeast of Jacumba. The holdings comprise 8 claims located along an outcrop of feldspar and silica that can be traced for a distance of five miles. The spar is of good quality. Some shipments of spar and clear silica have been made. Owners, A. W. Smith and E. Carson, San Diego, California.

Bibl: State Mineralogist's Report XXI, p. 359.

Mesa Grande Deposit is in Sec. 26, T. 11 S., R. 1 E., S. B. M. On this property a large pegmatite dike, containing segregations of feldspar and silica outcrops in the granite for a distance of 1000′. A 25-foot tunnel at one point exposed 3′ of feldspar. On account of its inaccessibility, no shipments have been made.

Moore Deposit is in Sec. 36, T. 17 S., R. 8 E., S. B. M., 4 miles east of Jacumba. Present owner of this property is unknown.

Some feldspar and mica were shipped in 1928 by a Mr. Gasaway. Present exposures indicate that the silica, feldspar and mica are so intimately mixed as to make it practically impossible to separate them.

Bibl: State Mineralogist's Report XXI, p. 359.

Mykrantz Deposit is on the San Vicente Grant, 4 miles south of Ramona.

Segregations of silica and feldspar in a pegmatite dike outcrop along a length of about 200′. The width of these outcrops is about 20′. An 8-foot hole sunk at one point shows in the bottom, 4′ of feldspar having a K_2O content of 12.5%.

Bibl: State Mineralogist's Report XXI, p. 359.

Osborne Feldspar Deposit is located 1½ miles west of Campo and about one mile north of the San Diego and Arizona Railroad in Sec. 21, T. 18 S., R. 5 E. A number of claims have been located and patented along extensive outcrops of spar. The material exposed is of good quality. R. C. Osborne, 2246 Fifth Avenue, San Diego, California, is the owner.

Development consists of opencuts and shallow shafts.

Bibl: State Mineralogist's Report XXI, p. 359.

Pacific Mine of the *Standard Sanitary Manufacturing Company* is 5 miles north of Campo, on a ridge south of Cottonwood Creek. Owner, Standard Sanitary Manufacturing Company, Richmond, California; F. A. Kales, manager.

This deposit of feldspar, which has been worked since 1924, is perhaps the largest and most productive yet developed in the State. A massive outcrop of silica and feldspar occurs in the granite. The strike is northeast; the dip is to the southeast. The total width is from 300′ to 500′ and the outcrop is traceable for some 1600′. The feldspar occurs in segregated veins or layers, in the silica and they also contain boulders of quartz which are sorted out when mined. The spar is massive and of good quality. In places, a thickness of about 30′ was observed.

The deposit has been developed at four different levels, on the mountainside by means of opencuts. The floor of the lowest pit is approximately 400′ below the top of the face in the upper pit. The lowest opening was the original one. It was worked for a width of 200′ and the height of the face was about 75′ when abandoned. The next cut, which is 100′ above, is 75′ long, 50′ wide and 20′ high. Work on these two lower openings ceased some three years ago.

Present workings are confined to the two upper levels. The lower one of these is approximately 100′ above the abandoned workings described above. It consists of a cut some 200′ long by 80′ wide, the face of which is approximately 100′ high. Of this height the lower 30′ is feldspar, the remainder being largely silica. The top level is 125′ higher up the mountain. The pit is 50′ wide by 20′ high, the entire face consisting of mixed spar and silica.

Material from the upper cut is dumped into a chute which discharges into cars at the level of the next lower opening and is trammed some 200′ to the top of the gravity incline which also serves the lower workings.

From incline cars, material is dumped into 40-ton storage bin at top of the crushing plant; from the bin it passes over a one-inch grizzly, oversize going to 10″ x 20″ Blake crusher, which crushes to 3″. The 3″ material goes to a revolving screen 4′ long, with 3″ openings. Here water is added to wash the material. The undersize goes to a revolving screen 8′ long, where it is screened to ½″. The oversize from both screens goes to a sorting belt and thence to receiving bins. The sorting is done by six women who make three products, No. 1 grade, No. 2 grade, and waste.

From receiving bins, material is hauled in a 10-ton truck 5 miles to the company's mill at Humphrey's, a station on the San Diego and Arizona Railroad. These trucks dump onto a platform which is raised by a derrick and dumped into a 100-ton bin; thence by roll feeder to 'chaser' mill and tappet screens; oversize from screens to two 6′ x 22′ tube mills which are in close circuit with the screens by means of an elevator. Undersize from screens goes to an Emerick separator; thence to bins and one Bates packer.

Three products are made: Spar to be used in the pottery trade is 200-mesh; for enamel ware it is 100 to 150-mesh; and for the glass products 65 to 100-mesh. Capacity of the plant is about 50 tons per day.

Power for the mill is generated by a 240-h.p. Fairbanks-Morse full diesel engine, direct-connected to a generator. Motor drives are provided for the various machines. A 25-h.p. Fairbanks-Morse semi-diesel engine provides power for the crushing plant at the mill. Two 10-h.p. Fairbanks-Morse oil engines operate pumps which supply water for the crushing plant.

When operating at full capacity 35 men and 6 women are employed.

Analysis: SiO_2 66.10; Al_2O_3 19.20; Fe_2O 0.08; CaO 0.40; MgO 0.18; K_2O 10.73; Na_2O 3.27.

Bibl: State Mineralogist's Reports XVII, p. 376; XXI, pp. 359–360.

Pilz Deposit is in Sec. 28, T. 18 S., R. 2 E., S. B. M., 4 miles west of Tecate. Holdings comprise 6 claims. Owners, Paul and Walter Pilz, Tecate, California.

A trench 30′ by 6′ deep has exposed boulders of feldspar in silica in a pegmatite dike. When broken, the spar, which is of good grade, is easily separated from the silica. There is a seventeen-mile haul to Jacumba.

Two men employed.

Ward and Williams, of Boulevard, California, shipped several cars of feldspar in 1929 from a deposit which is in McCain Valley, two miles north of Boulevard.

White Rose Mine is 6 miles north of Campo in Sec. 17, R. 5 E., T. 17 S., S. B. M. Elevation 3500′. Former owner, *Globe Tile and Porcelain Company,* Hynes, California.

Six carloads of feldspar were shipped by the owners in 1928.

The outcrop can be traced for about 3000′ along a N. 15° W. course; the dip is vertical.

Tulare County.

Carter Feldspar Deposit. It is situated one-half mile east of Three Rivers, on the ridge east of Kaweah River, about 21 miles east of Woodlake Junction. Owner, F. M. Carter, Three Rivers, California.

White crystals of orthoclase occur in a pegmatitic granite in seams and kidneys 6″ to 8″ in width. Idle.

Bibl: State Mineralogist's Report XV, p. 911.

Britton Ranch Feldspar Deposit. It is situated in Secs. 23, 24, 25, T. 17 S., R. 29 E., at Three Rivers. Owners, Mrs. Eureka Williams and Nellie Britton, Three Rivers, California.

There are a number of massive outcrops of feldspar and silica on this property. It is an orthoclase feldspar of good quality. Undeveloped.

Bibl: State Mineralogist's Report XV, p. 911.

Goodale Feldspar Deposit. It is situated near Lemon Cove. Owner, C. E. Goodale, Lemon Cove, California. Feldspar of good quality has been shipped from this deposit in years past. Idle.

Bibl: State Mineralogist's Report XV, p. 911.

Honora Realty Company, Adolph Levis, president, owns a deposit of feldspar situated in the NE. ¼ of NE. ¼ and SW. ¼ of SW. ¼ of Sec. 15, T. 18 S., R. 27 E., M. D. M., 1½ miles from Lemon Cove. Some feldspar of good quality has been shipped from this deposit. Idle.

Bibl: State Mineralogist's Report XV, p. 911.

Yokohl Valley Feldspar Deposits. Shipments of feldspar have been made from these deposits by the ranchers of this section.

Bibl: State Mineralogist's Report XV, pp. 911–912.

SILICA

Alameda County.

San Francisco and San Joaquin Coal Company, 328 Montgomery Street, San Francisco, had a deposit of sand at Tesla, Corral Hollow. It is in Sec. 32, T. 3 S., R. 1 E.

The sand occurs in a twenty-foot bed above the coal vein and between a bed of gray clay (used for building brick) on the hanging wall and a bed of fire clay on the footwall. The bed strikes N. 70° W., with a dip of 60°. The outcroppings are plainly visible across the hills in a general east-west direction. Sand was first shipped to Stockton in 1901. The bed was worked through a 500-foot tunnel. It is a fine quartz sand and was washed by long sluice boxes onto tables to free it from particles of light clay. About 600 tons were shipped in a season. Idle.

Bibl: State Mining Bureau Bull. 38, p. 276.

Amador County.

Silica occurs in the counties of east-central California both in vein and placer deposits. Besides these, there are deposits of white sand mixed with clay in Amador and Placer counties, which have

been utilized in the pottery and brick business but which near Ione, Amador County, also were the basis for the manufacture of glass and sodium silicate during the period of the World War and for a time thereafter. The white sand was separated from the kaolin and the dark minerals by washing and tabling. These operations could not compete with the cheaper imported sand which came back on the Pacific Coast market after 1922.

The sandy clay of the Ione (Tertiary) beds is distributed over a length of 12 miles and a width of four and one-half miles in the western part of Amador County but the beds extend northward into Sacramento County and southward into Calaveras. Due to distance from railroad, there has been no development of such beds in these last two counties, although the sand industry of Amador County was important for many years.

Only a few of the pits in the deposits near Ione have been opened particularly for their silica content. The clay beds lie nearly flat with a westerly dip of only a few degrees, and have generally only a soil and sand overburden varying from a few inches to 20 feet, though in a few places, as southeast of Buena Vista, the beds are covered by tuff, breccia and sandstone. The white clay apparently came from rhyolite ash flows which are directly over the older series of gold-bearing gravel channels in the Sierra Nevada. This material was mixed with the quartz sand of those early rivers and was swept down into the shore waters of the inland sea which then covered the Sacramento and San Joaquin valleys. An average analysis of the white sandy clay substantiates such an origin. Such material carries about 70% silica, 20% alumina, $1\frac{1}{4}$% iron oxides, 0.3% CaO and 0.2% MgO. Samples with less sand show up to 34% dry weight of alumina. With increasing iron, and decreasing free silica, the clay becomes mottled red and yellow. Brown lignite is interbedded with the clay usually at a depth of 80′ to 125′ but at times within 40′ of the surface. This lignite would ordinarily mark the limit of clay mining, although with the large available supply, pits have seldom been carried to such depths because of the cost of drainage and other increased working costs.

Statistics of glass sand production in Amador County show the first record of output in 1904. Important production began in 1910 and from then to 1922, inclusive, a total of 81,286 tons of silica sand, worth $261,533, was shipped from the county.

The Ione 'fire-sand' and clay are used by potteries and brick plants over most of the state.

W. D. Amick Property is one-half mile from Ione and includes a white sand deposit composed of from 70% to 80% white quartz sand and 20% to 30% kaolin. There is an overburden of from 2′ to 6′ of soil, sand and gravel. In the earlier operations the deposit was worked by drifting from an open pit. The last operators, who worked from early in 1919 to 1922, mined by stripping the overburden, blasting the white sand from the bottom and caving the bank, 12′ to 18′ high.

The sand was separated from the kaolin by pulping the bank-run material, pumping it to the plant where drag classifiers removed the sand and then running the sand over James ore concentrators which took out the heavy black mineral grains composed principally of chromite and iron oxides which would act as undesirable coloring

agents. Sand taken directly from the classifiers before tabling carried 94% silica and sold to Patterson Glass Company, Stockton. The tabled sand carrying 98% silica was used entirely for making sodium silicate. The kaolin, which was settled as much as possible in a series of redwood tanks and then put through filter presses and sun dried, was sold for high-grade pottery and heavy hotel ware. Twenty men were employed. The daily output was 25 tons of sand and 5 tons of kaolin. The machinery and equipment was removed from the property after operations ceased.

Arroyo Seco Grant contains about 33,000 acres in Townships 5 and 6 N., Ranges 8, 9 and 10 E., and includes most of the developed and undeveloped sand and clay deposits of the Ione district and the adjoining section of Sacramento County. Address, Stephen E. Kieffer, 57 Post Street, San Francisco. G. A. Starkweather took a lease on the clay deposits in 1926 and many of the pits have since been subleased to Mark Bacon et al., who have been operating either as contractors or for their own accounts. The workings on this grant from which sand is or has been produced are separately described herein. A map of the grant and nearby properties is shown as Plate VI in Bulletin 99 of the State Division of Mines.

Core drilling done on the grant in 1925 and 1926 showed large but indefinite reserves of clay and sand at various depths down to 246 feet. There is no likelihood of these deeper beds being opened as long as deposits at or near the surface remain unworked.

Barber (Shepard) Sand Pit is three-fourths mile east of Ione on the Amador Central Railroad.

The deposit is overlain by 6′ to 10′ of mottled red, sandy clay carrying nodules of red iron-oxide. The white sand which is up to 20′ thick but averages 16′ has been worked by running wide drifts 12′ to 14′ high and opening out rooms, leaving pillars at about 25′ centers. No. 2 stumping powder is used for blasting. The output has been at the rate of about 15,000 tons a year. Dietrich[1] reported a test of a sample from this pit and discussed its ceramic qualities. He classed is as a 'fire-sand' consisting of a 'fine-grained quartz-mica-feldspar sand with sufficient fire clay to render it weakly plastic. It contains 48.4% of +200-mesh sand, and a high percentage of the—200-mesh material is nonplastic.' A chemical analysis by Gladding, McBean and Company showed 71.22% SiO_2, 19.27% Al_2O_3, 1.23% Fe_2O_3, 0.21% CaO, 0.34% MgO, and ignition loss 7.73%. It is used largely for fire brick and other ceramic products. The sand is hauled in cars by a horse from the mine to the railroad cars, only a few feet distant.

Carlile Clay and Sand Deposit. Owner, Mrs. Sarah E. Carlile, Ione. The deposit is on 60 acres of land in W. ½ of NW. ¼ Sec. 8, T. 5 N., R. 10 E., four miles from Ione and 2.8 miles by road from the nearest railroad spur.

In February, 1927, a bed of white sandy clay, overlain by 2′ to 7′ of brown clay had been stripped over an area about 80 feet square. E. E. Tremain, lessee, was erecting a plant to dig and wash the material. Digging was to be done with a dragline scraper. The washing plant consisted of several hundred feet of sluices with sand traps, and

[1] Dietrich, W. F., Clay resources and ceramic industry of California, State Div. of Mines and Mining, Bull. 99, p. 261, 1928.

eight large clay-settling tanks. No work had been done besides the stripping mentioned, to determine the extent of the deposit.

Clark Sand Pit. Owners, N. Clark and Sons Company, Alameda, California. It is 1.8 miles north of Carbondale railroad station by road.

An area of perhaps five acres has been worked to depths varying between 12′ and 25′. The deposit is white quartz sand with comparatively little white clay. It is overlain by 1′ to 6′ of soil which contains a great deal of the impure, sandy concretionary iron oxide characteristic of the soil in this region. Most of the mining has been in open pits and was done by hand or steam shovel, but in one place was done by running wide drifts which were high enough to permit backing a truck underground.

This property was idle at the time of the last visit, but was operated for many years. During the war, sand from it was shipped to Stockton where, after washing it, it was used by the Patterson Glass Works for making glass. During the first half of 1917, it was stated that the value of window glass made in that plant, utilizing sand from this land and from the Amick ranch near Ione, was about $350,000.

Ione Fire Brick Company uses white quartz gravel and sand in the manufacture of fire brick at their plant near Ione.

The 'Grog' pit is two miles southeast of Ione near the Bacon Red Clay pit. A bank 6′ to 12′ high is worked. It contains principally small, partly-rounded quartz gravel with some sand and little clay.

The 'Sand' pit is near the 'Grog' pit and contains a white 'fire-sand' very similar to that in the Barber pit, carrying, according to Dietrich's[1] tests, 45% of 200-mesh sand. The above products are mixed with Lincoln Clay for making fire brick. Only two or three men are employed in the dry season at these pits.

May E. Newman Estate owns property formerly operated by J. Newman as the *Newman Clay Company.* It is one mile southwest of Ione in Secs. 20, 30 and 31, T. 6 N., R. 10 E., and the pits immediately adjoin the line of Amador Central Railroad. The old pits, which were worked for years south of the railroad, produced principally fire-sand as classified by Dietrich. In 1927, these pits had been worked up to the property line and a new pit was opened just north of the railroad and the shipment of red mottled clay started. This is said to carry a little more sand than the Bacon red clay.

In vertical section, from top to bottom, the new pit shows 25′ of overburden, 10′ of red mottled clay and 15′ of white sand, only the last-named stratum being of interest as a possible source of silica. It is stated to contain about 71% silica. Dietrich[2] has tested samples from the property and discussed their ceramic characteristics.

BIBL. (AMADOR COUNTY)

State Mineralogists's Reports XIV, pp. 5–11; XIX, pp. 94–96; XXIII, pp. 134–144; Bull. 38, pp. 206–210; Bull. 99, pp. 49–63; pp. 353, 354, 358, etc.; Prel. Rept. 7, pp. 38, 39.

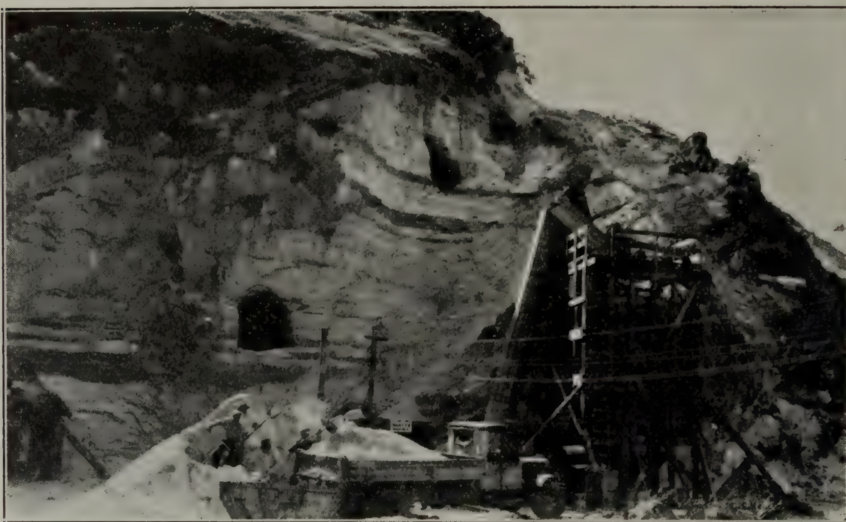
Calaveras County.

Iron Rock Mines, one of the Carson Hill group of claims near

[1] Dietrich, W. F., *op. cit.*
[2] *Idem.*

Carson Hill, was worked a short time in 1924 for white vein quartz, which was shipped out over the line of the Sierra Railway of California.

There are other large white quartz veins outcropping on Carson Hill, which could be utilized if demand were sufficient and if freight rates permitted.



Silica sand deposit of Silica Company of California, Ltd., near Brentwood, Contra Costa County.

Washing and leaching plant of Silica Company of California, Ltd., near Brentwood, Contra Costa County.

Contra Costa County.

Silica Company of California, Ltd. The silica sand deposit operated by this company is located on Stone House Ranch, $3\frac{1}{2}$ miles south-

west of Brentwood and a like distance from the Southern Pacific Railroad. The deposit is $\frac{1}{4}$ mile off the Marsh Creek Highway and the washing and treatment plant is at the intersection of the highway and the railroad, approximately 3 miles from the mine.

The company officials are: R. Marvin Greathouse, president; T. M. Monell, secretary. Home office, 503 Merchants Exchange Bldg., San Francisco. Local office at the plant, post-office address, Brentwood.

This bed of silica sand has been known for a number of years, but its development by the present company did not begin until 1930. The deposit consists of very evenly-graded, fine, compact, nearly-white silica sand. It is well exposed along the face of a hill, dipping north at an agle of approximately 30°. The foot and hanging walls are sandstone. The distance between the walls is 60′ and the bed is exposed for 180′ along the slope. It has been proved on the surface for several thousand feet and dips to an unknown depth. A main haulage level has been driven in 600′. The sand which stands well is stoped out in rooms 15′ by 60′ by 180′ with 15-foot pillars between. It is drilled and dynamite is used to loosen the material, which disintegrates freely after each shot. It is then hand-trammed to a bucket elevator and loaded in bins for transfer by truck to the washing plant.

About 10 men are employed in the mine and 20 at the plant. The latter consists of washing, screening, and leaching departments. The sand is well graded and most of the past year has been spent in developing a leaching process to reduce the iron content to 0.045%, the requirement for 'Flint' glass use. Production to date has been 35,000 tons, most of which has gone into the steel foundry trade. For this use only washing and screening is required. When fully developed, it is expected that the output will run from 60,000 to 100,000 tons annually, and that a large proportion will be used by glass manufacturers.

El Dorado County.

Brandon Silica Deposit, Chas. Brandon, owner, Shingle Springs.

A quartz vein 10′ to 35′ wide outcrops for a length of 250′. The quartz is white but shows a few small flakes of included country rock and some iron stains. The deposit is located $1\frac{1}{2}$ miles from Flonellis spur on the Placerville branch of the Southern Pacific Railroad. Idle.

Bibl: State Mineralogist's Report XXII, p. 445.

Coon Hollow placer mines, a mile south of Placerville, have supplied quartz cobbles in the past but there has been no production there recently.

Snow Silica Deposit, owned by *Spicky Polish Corporation,* 1401 Third Street, San Francisco.

A large vein of massive white quartz outcrops just east of where the Placerville and Mosquito road crosses White Rock Canyon, $4\frac{1}{2}$ miles northeast of Placerville. The vein strikes northwest and is exposed for at least 600′ along its strike. Where exposed by workings for a depth of 20′, over a length of 150′, it has a width of 25′ on the surface. The sections next to walls are slightly iron-stained but the quartz itself is remarkably pure and in the central part of the vein is perfectly white.

Several carloads of silica were produced in 1919 and some in 1925; also in 1929. One-half a mile northwest of this deposit is another

large outcrop of pure-white quartz exposed on the surface for a width of 40′ to 100′ and a length of 160′. Undeveloped.

Bibl: State Mineralogist's Report XXII, p. 446.

Imperial County.

Coyote Mountain Silica Deposit. A bedded deposit of silica sand occurs in the Coyote Mountains, in Secs. 1 and 2, T. 16 S., R. 9 E., S. B. M., on the holdings of the *Columbia Cement Company.* The deposit is located 7 miles north of Coyote Wells, a station on the San Diego and Arizona Railroad.

The bed of silica sand is 50′ thick and can be traced for one-quarter of a mile along a gulch west of No. 3 Marble Quarry. The sand is clean and white, with low iron content and is suitable for the manufacture of glass. During 1921 and 1922 twelve hundred tons of this sand was shipped to Los Angeles and the price received for the product was $6 per ton.

Bibl: State Mineralogist's Reports XVII, p. 271; XXII, pp. 280–281.

Fish Mountain Silica Deposit. This deposit of silica sand is located in Fish Mountains, in Secs. 10 and 15, T. 14 S., R. 9 E., S. B. M., 14 miles north of Coyote Wells, a station on the San Diego and Arizona Railroad. Owner, W. A. Waters, Dixieland, California.

Analysis and screening test made by John T. Rice, Chemist, is as follows:

	Sample of silica plus 50-mesh and 50% of the original	*Sample of silica minus 50-mesh*
Silica (SiO_2)	86.00%	75.06%
Aluminum Oxide (Al_2O_3)	8.39	19.23
Iron Oxide (Fe_2O_3)	1.18	0.60
Calcium Oxide (CaO)	3.06	3.45
Magnesium Oxide (MgO)	Tr.	0.11
Alkalies	0.11	0.09
Loss in Ignition	1.24	1.27
Total	99.95%	99.87%

Undeveloped.

Bibl: State Mineralogist's Report XXII, p. 281.

Los Angeles County.

Muroc Silica Deposit. It consists of a wide vein of quartz, pure white in color, with low iron content, situated 18 miles east of Lancaster and 13 miles southeast of Muroc. The deposit was formerly worked by the Western Silica Company, of Los Angeles, which company shipped a large tonnage to Los Angeles in 1923. The material shipped was reported to run 98% silica. Owner, Edward Preste, Montrose, California.

Analysis

SiO_2	98.05%
Fe_2O_3	0.03
Al_2O_3	0.96
CaO	0.49
Total	99.98%

Bibl: State Mineralogist's Reports XV, p. 513; XIX, p. 61,

Quartz Mountain Deposit. It consists of a massive outcrop of quartz situated on the Earle Ranch, 4 miles southwest of Lancaster. Owner, E. T. Earle Estate, of Los Angeles.

The quartz was hauled from the quarry to Lancaster, from which it was shipped by rail to Los Angeles for manufacture of glass. It is white, milky quartz, quite free of impurities. Idle.

Analysis

SiO_2	96.86%
Fe_2O_3	0.01
Al_2O_3	2.13
CaO	0.39
Total	99.39%

Bibl: State Mineralogist's Report XV, p. 513; Bull. 38, pp. 277–278.

Madera County.

Several occurrences of massive, white vein quartz are known in this county. These are associated with the copper belt, in the foothill area and are similar to those farther north in Mariposa County.

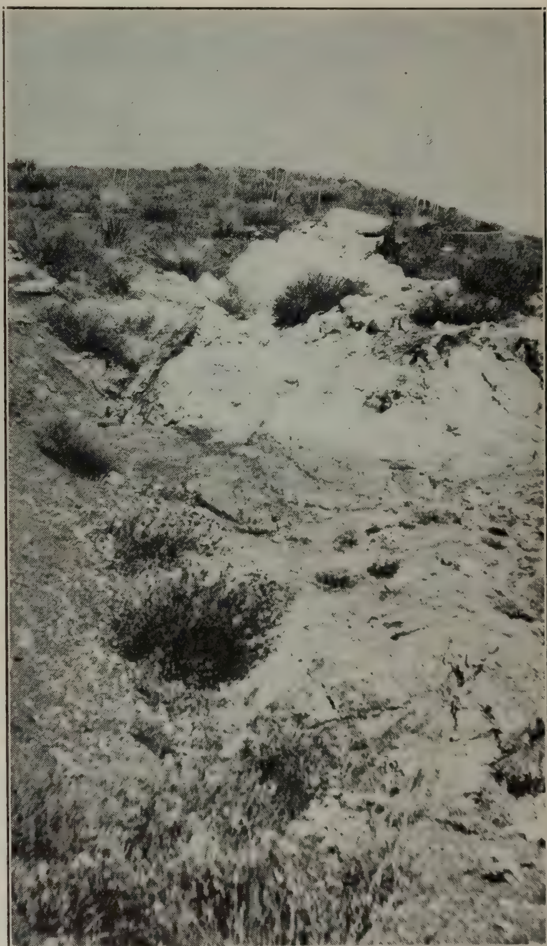
Buchana Property. A large outcrop of white quartz occurs on this property in the Daulton District, within a mile of the Berenda-Raymond branch of the Southern Pacific Railroad. Undeveloped. Alex Erickson, Box 207, Madera, California, owner.

Bibl: State Mineralogist's Report XXIV, p. 344.

Mariposa County.

White Rock Silica Deposit is on patented land, owned by J. H. Helm and P. Carmean, Le Grand, California.

The deposit consists of a massive outcrop of white, glassy quartz,



Quartz Mountain Silica Deposit, 4 miles southwest of Lancaster, California.

practically pure silica but with occasional spots showing a little iron stain. The outcrop is on top of a knoll, at an elevation of 1117′ and is a noted landmark for miles around, being visible from the valley highway. This massive vein occurs near contact of slate on the west and a granite intrusion of almost circular form. One mile southeast of this exposure there is another similar outcrop, apparently on the same vein but somewhat smaller and also several parallel veins of bull quartz which outcrop at intervals.

The amount of silica in sight has been variously estimated at one to three million tons. Two carloads of silica were shipped to Los Angeles in 1926 and some shipments in 1929. The nearest shipping point is Le Grand, a distance of 14 miles.

Bibl: State Mineralogist's Report XXIV, pp. 150–151.

Close-up view of White Rock Silica Deposit, Mariposa County.

Monterey County.

Del Monte Products Company, A. J. Gunnell, president and manager, Crocker Building, San Francisco; C. S. Olmstead, plant superintendent, Pacific Grove, California.

This company is producing sand on a large scale from two deposits lying between Pacific Grove and Carmel. The deposit consists of large wind-blown dunes extending along the coast for several miles. The principal operations are at the Lake Majella plant, three miles west of Pacific Grove near Asilomar. Sand both from the Lake Majella dunes and the Fan Shell Beach workings, 4 miles farther down the coast is treated in Majella plant. At the plant the sand passes over Overstrom tables, removing the garnet, iron and mica. The sand is then dried, elevated and passes through air separators which remove the last traces of mica. The capacity of the plant is 25 tons per hour. The products are glass sand, sand-blasting and foundry sand, building sand, mortar and stucco sand, filter sand and fine sand for use in the manufacture of roofing paper.

Eight men are employed.

Bibl: State Mineralogist's Reports XVII, p. 157; XXI, pp. 54–55.

Lapis Sand Plant, owner, *Bay Development Company;* Frederick Maurer, president; E. H. Rix, secretary and manager; Chas. Hall, superintendent, Lapis plant. Home office, Foot of Fourth Street, at Pier 54, San Francisco. The company owns 435 acres at Lapis, a station on the Southern Pacific Railroad. The property is practically all composed of sand dunes parallel to the coast of Monterey Bay and varies in elevation from sea level to 100′ above.

The sand is being produced at two workings. Number 2 sand is obtained from the dunes and No. 4 sand from beach workings. The output is consumed in building and construction work for concrete and mortar, also for sand-blasting, marble cutting, and as locomotive sand. The sand is hard and sharp and particularly well-suited for sand blasting and cutting but contains too much iron to be used for glass making. Production 160 cars per month. Eight men employed.

Bibl: State Mineralogist's Reports XV, p. 614; XXI, p. 55.

Meadows Gulch Deposit. It is situated on the James Meadows Tract, about 10 miles southeast of Carmel. Owner, James Meadows. Under lease to Albert Otey, Carmel, California.

A deposit of light-colored, fine-grained siliceous shale rock, which is easily split in slabs from 1″ to 3″ or 4″ or more in thickness. The material occurs in ledges 3′ to 4′ wide on both sides of Meadows Gulch which opens into Carmel Valley.

The material is used mainly as a veneering for residences, in fireplaces and as flagstones. Some production of sand has been made from a deposit owned by Mr. Otey, at the mouth of the Carmel River.

Bibl: State Mineralogist's Report XXI, p. 57.

Otey Deposit (see Meadows Gulch Deposit).

Prattco Sand Pit No. 4. This sand deposit is situated 1½ miles North of Seaside on the Southern Pacific Railroad and contains a total area of 30 acres. Owner, Pratt Building Material Company, San Francisco; C. F. Pratt, president; Howard Center, secretary; L. H. Walmack, plant superintendent. The holdings include both beach and dune deposits.

The entire output is used for building and construction work and sand-blasting. Six men are employed and output averages about 100 cars monthly.

Bibl: State Mineralogist's Report XXI, pp. 55–56.

Placer County.

Silica has been produced from this county in the form of sand from the clay beds near Lincoln, and as cobbles from the ancient river channels in the foothills and lower mountains. There are quartz veins sufficiently pure for most uses but they have not been utilized as yet.

The deposits of Ione age near Lincoln have been extensively worked by three companies. The ancient channel deposits have been utilized in a small way at irregular intervals, depending on demand which calls for the production of usually a few hundred tons at a time under contract. Although the Lincoln deposits are in the main similar to those at Ione, occurring in the same manner and of like chemical analysis, there has not been so much attention paid as at Ione to the

production of silica as such, most of it going into clay products. The demand for the Lincoln clays, however, which depends partly on the characteristics imparted by the silica content, is widespread. The total silica content and the percentage of +200-mesh sand are both generally less than in the deposits at Ione. The range in chemical composition according to published analyses[1] is: SiO_2, 46.8% to 58.3%; Al_2O_3, 26.02% to 33.5%; Fe_2O_3, 2.14% to 4.53%; CaO, 0.54% to 1.28%; MgO, 0.12% to 1.07%; K_2O and Na_2O, 0.32% to 1.02%. The content of +200-mesh sand varies from less than 1% to 32% in most of the beds.

For a description of the deposits and plants of *Clay Corporation of California, Gladding McBean and Company* and *Lincoln Clay Products Company,* reference should be made to California State Division of Mines and Mining Bulletin No. 99, and to Report XXIII of the State Mineralogist.

Davenport Deposit. M. E. Davenport, Auburn, owner.

A wide vein of pure-white quartz is found on the side of the canyon of American River about one mile from Auburn (Railroad Street station). It could be cheaply mined because of its width and its position on the steep hillside.

Harry McCormick, Alta, was a shipper of quartz cobbles and boulders in 1927 and 1929 from an old river gravel deposit near Alta.

F. R. Payne, Dutch Flat, was a shipper of quartz cobbles and boulders in 1927.

The Polar Star and adjoining hydraulic mines near Dutch Flat have been the source of supply of such quartz at irregular intervals for many years. W. P. Nicholls, Jr., owner, Berkeley. The quartz boulders remained in the old mine pits after hydraulicking was stopped and they have been gathered up and loaded on wagons and trucks and hauled about two miles to the railroad for shipment. Some boulders too large for handling are broken up to one-man size by blasting. The quartz has been used at steel mills, and for making fire-brick.

Dan Sullivan, Alta, shipped quartz cobbles from an old gravel channel near Gorge, several years ago.

There are other such accumulations of quartz cobbles and boulders at old hydraulic mines in other sections of Placer County. Except for those which are within a short distance of the railroad there is little chance to work these at a profit, as the price paid is too low to permit hauling very far.

Glass sand has been reported[2] in Sec. 8, T. 11 N., R. 7 E., west of Loomis. So far as known, it has not been developed.

Riverside County.

Alert Ranch Deposit, formerly known as Mountain View Ranch, is described elsewhere herein under Feldspar.

American Encaustic Tiling Company Deposit, near the town of Murrietta, is fully described under Feldspar.

Brown Ranch Deposit. (See under Feldspar.)

[1] Cal. State Min. Bur. Bull. 99, pp. 354, 355.
[2] Cal. State Min. Bur. Bull. 38, p. 278.

Coahuila Brave Deposit is described under Feldspar.

Ensley-Spaulding Deposit. (See under Feldspar.)

Hemet Silica Mine. The *San Jacinto Rock Products Company;* Geo. Green, president, San Jacinto, California, worked a silica deposit which is located in Sec. 27, T. 5 S., R. 1 W., S. B. M., 3 miles south of Hemet on the Polly Butte. This property, which was formerly worked by the *Hemet Silica Company,* is at an elevation of 1850 feet.

The deposit consists of a series of lenses of quartz in granite, having a maximum width of about 75′; strike N–S., dip 80° E.

The principal development is on the northwest slope near the top of the hill. It consists of an opencut 25′ deep by 50′ long, exposing about 75′ of solid quartz. On account of the iron content, it is classed as second-grade silica. The product was hauled by motor truck to San Jacinto where the company had a grinding plant. This plant has been dismantled and moved to Nevada. Idle.

Bibl: State Mineralogist's Report XXV, pp. 504–505.

Jones Sand Deposit is on the old Hoag Ranch, 7 miles southeast of Corona, in Secs. 17 and 19, T. 4 S., R. 6 W., S. B. M. The American Fruit Growers branch of the Santa Fe Railway is three-quarters of a mile northwest of the deposit. Owner, A. E. Jones, Corona, California.

The deposit forms a chain of four low hills. The axis of these hills has a general east-west direction and they rise approximately 150′ above the bottom of the canyon. At the top they are only a few feet across, while the width at the base is about 250′. The total length is 1200′ to 1500′. They appear to be entirely composed of unconsolidated sand, consisting of rounded grains of silica and containing but little, if any, visible impurities. The overburden consists of 1½′ to 4′ of sandy soil. It is reported that the raw material is 97.45% silica, and 97.54% after it is washed and screened. Also that the iron content varies from 0.09% to 0.11%. Idle.

Bibl: State Mineralogist's Report XXV, p. 505.

K. & K. Ranch Deposit is described under Feldspar.

Lang Deposit. (See under Feldspar.)

Last Chance Deposit. (See under Feldspar.)

Littlejohn Deposit. (See under Feldspar.)

Machado Deposit is described under Feldspar.
Analysis of the quartz from this deposit is as follows:

Silica	98.56%
Iron	0.01
Aluminum oxide	0.99
Lime	0.42

Bibl: State Mineralogist's Report XXV, pp. 505–506.

Morgan Ranch Deposit. (See under Feldspar.)

Patterson Ranch Deposit. Described under Feldspar.

Penny Deposit, comprising 95 acres, is 2 miles north of Murrietta. Owner, T. C. Penny, Elsinore, California.

Analysis of material from this deposit is as follows:

Silica	95.24%
Iron	0.02
Aluminum oxide	1.98
Lime	0.42

Perris Mining Company. (See under Feldspar.)

Spicer Silica Deposit is in T. 2 S., R. 4 W., 3½ miles east of Riverside, adjoining the Santa Fe Railway right of way, on the east.

Two lenses of quartz in the granite have been exposed by small opencuts. The strike is N. 65° W., and dip 55° SW. Included in the quartz is a narrow vein of feldspar. These two lenses, having a maximum thickness of 3′, are about 10′ apart in the granite and have been exposed for a length, along the dip, of 12′. Idle.

Bibl: State Mineralogist's Report XXV, pp. 506–507.

Temescal Canyon Silica Sand Deposit, comprising 640 acres, is located in Sec. 29, T. 4 S., R. 6 W., S. B. M., 7 miles south of Corona, in Temescal Canyon. Undeveloped. Owner, L. M. Freeman, 509 Citizens National Bank Building, Los Angeles.

Analysis

Silica, SiO_2	73.74%
Alumina, Al_2O_3	12.77
Iron, Fe_2O_3	1.03
Lime, CaO	5.25
Magnesium	3.04
Ignition loss	0.87
Moisture	1.22

Warren Deposit. (See under Feldspar.)

Bibl: State Mineralogist's Report XXV, p. 507.

Weir Ranch Deposit. (See under Feldspar.)

San Bernardino County.

Brine and Weiss Silica Deposit, comprising one claim, is 20 miles north of Barstow. Owners, Walter B. Weiss, of Los Angeles, and I. A. Brine, Barstow, California.

There is an outcrop of clear, white silica from 15′ to 20′ wide. Analysis shows it to consist of 99.6% silica. Undeveloped.

Emsco Ganister Deposits. Owner, Emsco Refractories Company; E. M. Smith, president; S. B. Findley, vice president and general manager. Local plant address, 5601 South Boyle Avenue, Los Angeles.

This company opened a quarry which is approximately 2½ miles northwest of Wilde, a siding on the Santa Fe Railroad.

It is a cone-shaped hill about 150′ high. The entire upper portion of this hill is composed of quartzite. It is probably 200′ thick. The strike is N. 35° W. and it dips 45° NE.

Development consists of an opencut and short tunnel, the portal of which was closed at the time of our visit. A bin and two houses were erected on the property.

The above-described property was abandoned and the company transferred its operations to a similar deposit which is approximately 9 miles east and slightly north of Victorville.

Here a quarry face has been developed which is 300′ long by 20′ high, in a wide belt of quartzite, the strike of which is East with dip 45° N.

This quarry is about one mile from the Southwestern Portland Cement Company's railroad, which connects with the Santa Fe at Victorville. Material is shipped to Los Angeles for the manufacture of fire brick.

There are three men employed loading with a gasoline-driven shovel.

Bibl: State Mineralogist's Report XXVI, pp. 302–303.

Kennedy or Atlas Fire Brick Company's ganister deposit is about 4 miles northwest of Wilde siding on the Santa Fe Railroad. This deposit is similar to the Emsco and is probably a continuation of the same quartzite belt. Owner, Mr. Kennedy, Daggett, California. Idle.

Bibl: State Mineralogist's Report XXVI, p. 303.

H. E. McKnight, of Los Angeles, has a deposit of 'Cornish stone' in Sec. 16, T. 7 N., R. 2 E., S. B. M. It is at Willis Wells on the east slope of the Ord Mountains, 20 miles north of Box S. Ranch. Holdings comprise 640 acres.

Bibl: State Mineralogist's Report XXVI, p. 305.

White Rock Deposit, consisting of 2 claims, is 24 miles west of Needles and 6½ miles south of the highway. It is about 10 miles southeast of Goffs. Owner, P. Gerber, 7364 Sunset Boulevard, Los Angeles.

It is reported that a 25-foot tunnel has been driven on a mixed quartz and feldspar segregation in the granite. The zone is 15′ to 18′ wide. Idle.

Bibl: State Mineralogist's Report XXVI, p. 305.

San Diego County.

American Encaustic Tiling Company owns a deposit of silica located 2 miles south of Boulevard and 6 miles west of Jacumba.

The deposit is a massive outcrop of quartz, about 60′ wide and 200′ in length which occurs on top of a ridge in the granite area between Boulevard and Jewell Valley. The quartz is clear, white and in the openings made along the outcrop are veins and bunches of feldspar associated with the quartz. The silica so far exposed seems to be free from iron stain. Idle.

Bibl: State Mineralogist's Report XXI, p. 375.

Beeman Deposit of sand is located between Vista and Oceanside. Owner, F. H. Beeman; former address, 1311 East 83d Street, Los Angeles.

Bibl: State Mineralogist's Report XXI, p. 375.

Benton Ranch Deposit. A number of bold outcrops of silica occur near Laguna Junction and 6 miles east of Descanso. These are northeast of the main highway to Jacumba.

The quartz is clear white and the outcrops are extensive. No attempt has been made to develop the deposits owing to their distance from railroad transportation.

Bibl: State Mineralogist's Report XXI, p. 375.

Borden Deposit is located two miles east of Carlsbad. Owner, Carol Borden, Carlsbad, California.

Undeveloped.

Burroughs Silica Mine, comprising 2 claims, is located in Jewell Valley, in Sec. 8, T. 18 S., R. 7 E., S. B. M., 4 miles southwest of Boulevard and 7 miles west of Jacumba. Owner, J. W. Risley, San Diego, California.

View of pit on Silica Sand Deposit. Crystal Silica Sand Company, Oceanside, San Diego County. Photo by J. A. Benell, president.

A massive outcrop of quartz 60′ long and 12′ wide and 20′ in height, occurs on the Burroughs claim in a decomposed granite. The quartz is clear white and free from iron stain and mica.

Analysis: Silica (SiO_2) 99.5%; iron (Fe_2O_3) 0.04%; alkalies 0.01%.

On the Delphos Claim, one mile east of the Burroughs deposit, is an outcrop of quartz located on the north slope of a rounded hill which is about the same size as the above-mentioned deposit.

Analysis: Silica (SiO_2) 99.2%.

These deposits are three-quarters of a mile from the railroad.

Bibl: State Mineralogist's Report XXI, p. 375.

Carlsbad Group. On this group of claims (described under Feldspar) and in their immediate vicinity, are numerous pegmatite dikes with many segregations of silica. These deposits are in T. 9 S., R. 4 E., about 14 miles northeast of Warner Hot Springs.

On account of their inaccessibility they are as yet undeveloped.

Crystal Silica Sand Company, 920 William Garland Building, Los Angeles, is extracting sand from a deposit which is located in Sec. 22, T. 11 S., R. 4 W., S. B. M., 5 miles east of Oceanside. Holdings comprise 104 acres. The deposit and washing plant are on the Escondido branch of the Santa Fe Railroad.

The deposit, consisting of clean, fine sand, forms the bulk of a low range of hills whose axis is east-west. Where opened, the over-

burden consisting of clay, is from 1′ to 15′ thick. The present workings consist of a cut 200′ long, 100′ wide and 40′ high at the face. Stripping is done with a dragline caterpillar tractor and scrapers. Material is brought directly to washing and screening plant by the dragline.

The company estimates that it has 50,000,000 tons of sand suitable for its purposes.

Washing and screening plant consists of ¼″ trommel to 2 pebble mills, bucket elevator to 3 Cottrell vibrating screens, 10- and 20-mesh, to 2 log washers; thence to 4 drag classifiers and to dewatering bins (400 tons capacity); thence to oil-fuel driers; by elevator to screen room; double deck 4′ by 5′ screens, 10- and 16-mesh, to 2 single-deck, 30-mesh screens; undersize to double-deck 60-mesh screens. Products go to 8 storage bins having a capacity of 50 tons each.

The capacity of the wet end of the mill is about 200 tons daily, while the driers have a capacity of 120 tons.

Analysis of the raw bank sand:

SiO_2	78.00 to 80.00%
Al_2O_3	6.00
CaO	1.96
MgO	1.02
Fe_2O_3	0.10

Analysis of glass sand:

SiO_2	90.00 to 92.00%
Na_2O and K_2O	2.86 to 3.25
Fe_2O_3	0.04 to 0.65
Al_2O_3	3.80 to 4.50

Plant of Crystal Silica Sand Company, Oceanside, San Diego County. Photo by J. A. Benell, president.

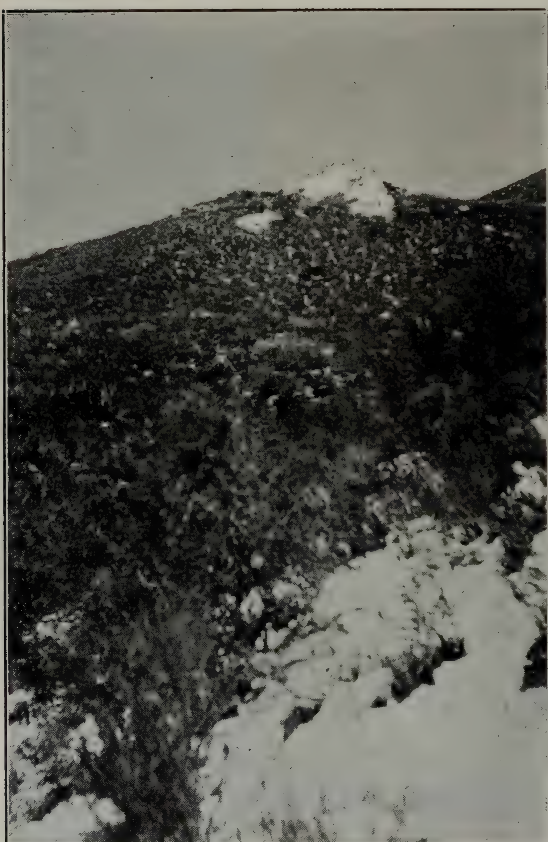
The following products are made:

Silica aggregate ¼ mesh
Special screen –16 mesh
Blast sand –16 and +80 mesh
Filter sands –16, +100; also –12 mesh
Stucco sands –16, +100; also –30 mesh
Stucco filler sand –50 mesh

Colloidial silica (plaster binder) –40 mesh
Core and parting sand –28, +150 mesh
Glass sand 2% on 16 and all on 80 mesh
Engine traction sand –28, +100 mesh
Sterilized play sand –20 mesh
Colloidial siliceous clay
(Precipitated) for pottery –40 mesh
Filler clay for pottery (from overburden).

Seven men are employed.

Dehesa Cornwall Stone Deposit is described under Feldspar.



Outcrop of silica, Flynt Silica and Spar Company's deposit, Boulevard, San Diego County.

Dos Cabezas Deposits. Outcrops of quartz occur one mile north of Dos Cabezas siding, on the San Diego and Arizona Railroad, in Sec. 22, T. 16 S., R. 8 E., S. B. M. These deposits are undeveloped but the outcrops are extensive and considerable clear silica could be developed. Owners, M. A. and M. C. Turner, San Diego, California.

Bibl: State Mineralogist's Report XXI, p. 375.

Flynt Silica and Spar Company's Deposit is described under Feldspar.

Lakeside Deposit is located 5 miles west of Alpine. Owners, Hardesty and Powers, of San Diego.

Outcrops within a distance of one mile along a general northwesterly strike. The principal outcrops are in Sec. 35, T. 15 S., R. 1 E., S. B. M. Associated with the quartz is some feldspar. Idle.

Bibl: State Mineralogist's Report XXI, p. 375.

Langer Deposit is described under Feldspar.

Marden Deposit is located 5 miles northeast of Jacumba. Fifteen claims have been located along outcrops of quartz that can be followed for several miles along their strike. Considerable tonnage has been

mined. The quartz is clear white, with a small amount of iron stain. Owner, Jack Marden, National City, California.

Bibl: State Mineralogist's Report XXI, p. 376.

Mesa Grande Deposit has been described under Feldspar.

Moore Deposit has been described under Feldspar.

Mykrantz Deposit has been described under Feldspar.

Osborne Deposit is 1½ miles west of Campo. Silica said to be of good quality occurs here associated with feldspar. Owner, R. C. Osborne, Oceanside, California.

Pacific Mine of the Standard Sanitary Manufacturing Company is fully described elsewhere herein under Feldspar.

Pilz Deposit is described under Feldspar.

Potrero Deposit is located in the range of mountains one mile east of Cottonwood Creek and about 8 miles west of Potrero.

A large outcrop of quartz 50′ wide, associated with feldspar, occurs on the crest of the ridge. The quartz is clear white and is reported to be very pure.

Due to its inaccessibility and distance from transportation, the deposit has not been developed.

Bibl: State Mineralogist's Report XXI, p. 376.

San Vicente Deposits. A number of outcrops of quartz occur on the San Vicente Ranch owned by J. W. Mykrantz, of Ramona, California. These outcrops have a general northeast strike and where exposed, are from 6′ to 12′ wide. The quartz is white but shows considerable iron stain along the fractures.

Bibl: State Mineralogist's Report XXI, p. 376.

Sweetman Deposit is located in Jewell Valley, 7 miles west of Jacumba. Owner, J. W. Sweetman, Jacumba, California.

The deposit consists of a number of outcrops of quartz that occur in the granite. Undeveloped.

Bibl: State Mineralogist's Report XXI, p. 376.

Walker Deposit is located in Jewell Valley, 7 miles west of Jacumba. Owner, Chas. Walker, Jacumba, California.

A massive outcrop of white quartz occurs on a small, round hill which appears to be largely made up of quartz. The quartz is clear white in places but shows considerable iron stain. Opencuts made on the east side of the hill have developed quartz 80′ in length by 20′ wide and 40′ high.

Bins and loading chute were installed and the product was hauled to Jacumba for shipment to Los Angeles. Was under lease to Jack Marden, National City, California. Idle.

Bibl: State Mineralogist's Report XXI, pp. 376–377.

Practically every deposit in San Diego County described or mentioned under FELDSPAR herein, may also be considered as a silica deposit and reference should be made to these for any deposits which are not here described under SILICA.

Shasta County.

Archer Deposit. This property comprises 45 acres situated in the Keswick district. It contains a large body of nearly pure quartz but carrying very low-grade gold values. Some of it was utilized in the past for flux at the copper smelter formerly operated at Keswick. Owner, Mrs. Clara Archer, 1453 Yuba street, Redding.

Stanislaus County.

Hammonds Silica Deposit (formerly *California Silica Co.*). A ledge of pure white quartz outcrops boldly in Sec. 4, T. 6 S., R. 6 E., on Del Puerto Creek, about 12 miles west of Patterson. Owner, Wm. N. Hammonds, Patterson, California.

The width of outcrop varies from 5′ to 20′. Analysis by Smith, Emery and Company: Silica 99.73%; alumina 0.21%; iron oxide 0.007%.

Undeveloped.

Bibl: State Mineralogist's Reports XIV, p. 633; XXI, pp. 216–217.

Silica Sand. A deposit of silica sand occurs in Sec. 20, T. 5 S., R. 7 E., M. D. M., about 6 miles west of Patterson. Holdings comprise 320 acres of patented land. Owners J. J. Cummings and Thomas Wolf, 2231 Ashby Avenue, Berkeley, California.

The sand is fine-grained, white to gray in color and is said to be 97% to 99% silica.

Bibl: State Mineralogist's Report XIV, p. 633.

Tulare County.

Miner's Silica Deposit. H. H. Miner, Sanger, California, has several deposits of quartz-silica and rose quartz in the vicinity of Worth and Success.

Guthrie Silica Deposit. H. W. Guthrie, White River, owns a silica deposit, the vein outcropping for about one-half mile. Some quartz crystals occur also.

Skid Road No. 1 Claim. A. P. O. Crabtree, Porterville, owner. This deposit of silica is reported to be three-quarters of a mile from a truck road, near Mountain Home, at the foot of Mt. Moses, northeast of Porterville.

Tuolumne County.

Some white vein quartz was shipped in 1926 from the Harvard Mine or nearby claims, a mile west of Jamestown, for use in stucco dash rock. This rock was found close to the line of the Sierra Railway of California.

ANDALUSITE, CYANITE, DUMORTIERITE AND SILLIMANITE

Description and Properties.

The minerals, andalusite, cyanite and sillimanite, differ in physical properties but have the same chemical composition. They are silicates of alumina having the formula $Al_2O_3.SiO_2$; Al_2O_3, 62.85%; SiO_2, 37.15%.

Sillimanite and andalusite both crystallize in the orthorhombic system, but their crystal habits are different. Andalusite is usually in coarse prismatic forms, the prisms nearly square in shape; also massive, imperfectly columnar, and sometimes radiated and granular. Sillimanite commonly occurs in long, slender crystals, not distinctly terminated; prismatic faces striated and rounded; often in close parallel groups, passing into fibrous and columnar massive forms, sometimes radiating.

Colors are similar, being gray, greenish, reddish, bluish, and brown.

Hardness: Andalusite 7.0–7.5. Sillimanite 6–7. Specific gravity: Andalusite 3.1–3.2. Sillimanite 3.2–3.3.

Cyanite, crystallizing in the triclinic system, occurs usually in long-bladed crystals, rarely terminated. Hardness 5–7; specific gravity 3.5–3.7; color, blue, gray, green, and brown.

Another mineral that is closely related to this group is *dumortierite.* Dumortierite, though differing somewhat in composition from the above, being a basic aluminum silicate ($HAl_8BSi_3O_{20}$) has proved to be similar in behavior in ceramic work so that it is now being mixed with andalusite in the manufacture of electrical porcelains.

Uses of Andalusite.

The use of andalusite minerals in the manufacture of spark plugs was first developed by Dr. J. A. Jeffrey, of the Champion Porcelain Company, Detroit, Michigan, and later in the production of laboratory ware, including crucibles, casseroles, evaporating dishes and other heat-resisting articles. Owning its own deposits in California and Nevada, this concern has ample supplies of raw material.

Uses of Cyanite.

Recent tests indicate that in firing electrical-porcelain saggers containing cyanite have a much longer life than those made from ordinary mixtures. Cyanite has likewise been used, more or less, experimentally, in spark plugs, for refractory brick, in electrical porcelain and chinaware and in glass and enamelware.

The *Vitrefrax Corporation,* of Los Angeles, produces cyanite from a large deposit in Imperial County, for use in the manufacture of various ceramic materials for the porcelain, white-ware and electrical insulator trade, and including super-refractories in the form of prepared grains, cements and finished raw materials; together with a line of refractory brick and shapes for the glass industry[1].

Products manufactured by this company have been described as follows:[2]

"The mullite products of the company constitute its most important line. The material is manufactured in several grades, one of which is made especially for the spark-plug industry. * * *

"The most important application of the mullite refractory material in its highest state of purity is in the form of glasshouse refractories, in which the company's product is gaining important recognition. Excellent service is being obtained in many commercial installations on the Pacific coast, while an awakening interest in the

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[1] Sillimanite, Kyanite, Andalusite, Dumortierite, by Alice V. Petar, U. S. Bureau of Mines I. C. 6255.

[2] Dietrich, W. F., The clay resources and ceramic industry of California, Calif. State Division of Mines & Mining, Bull. 99, pp. 121–122, 1928.

east has caused orders to be placed by a number of prominent glass manufacturers within the past year.

"For the general refractories trade, for use in heavy-duty boiler refractories and the like, a cheaper grade of mullite is manufactured and sold under the trade mark 'California Mullite.'"

Uses of Dumortierite.

Dumortierite is used with andalusite in the manufacture of porcelain for spark plugs. No commercial deposits of dumortierite have so far been developed in California, though some occurrences have been noted.

Dumortierite is a metamorphic mineral found in certain gneisses and schists; but rare in its occurrence.

Occurrences

Imperial County.

Dark blue boulders of dumortierite occur on the plains and in the dry washes about 25 miles from Ogilby.

Riverside County.

Massive dark blue dumortierite occurs one mile north of Big Four Mines, Pinacate District.

San Diego County.

A violet-red variety of dumortierite occurs near Dehesa and was described and analyzed by Schaller.[1]

Analysis

Silica, SiO_2	28.68%
Alumina, Al_2O_3	63.31
Titanium, Ti_2O_3	1.45
Iron, Fe_2O_3	0.23
Borates, B_2O_3	5.37
Water, H_2O	1.52
Total	100.56%

Bibl: Cal. State Min. Bur. Bull. 91, p. 195.

ANDALUSITE

Chiastolite is a variety of andalusite found in carbonaceous schists in knotty and long prismatic individuals having black inclusions of carbon arranged axially and thus forming black crosses seen in transverse sections.

Fresno County.

Chiastolite occurs near Chowchilla Crossing, on the old Fort Miller Road.

Kern County.

Chiastolite schists occur on Walker's Creek southeast of Bakersfield.

Mariposa County.

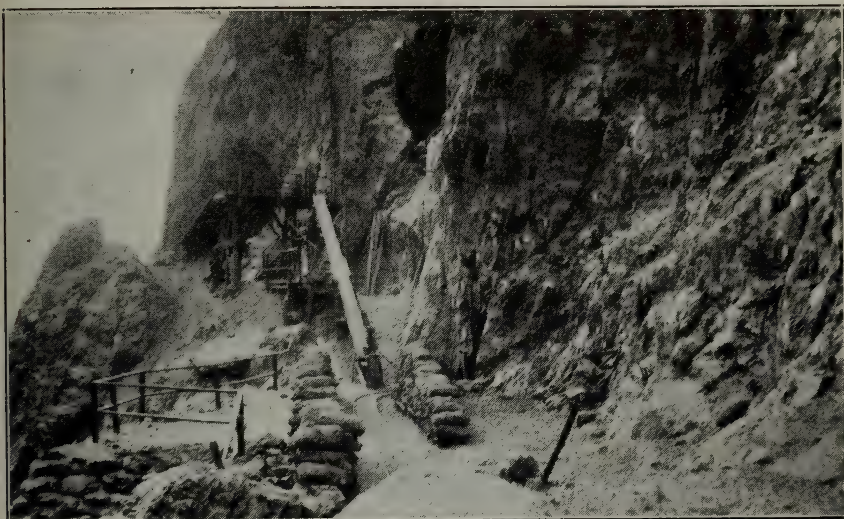
Chiastolite schists are abundant along the Chowchilla River. They were first reported by W. P. Blake.[2]

[1] Schaller, W. T., Dumortierite; Amer. Journal Science, 1905.

[2] Blake, W. P., Report on a geological reconnaissance in California, Pacific Railroad Reports, Vol. V, 1853.

H. W. Turner[1] in U. S. Geological Survey, Fourteenth Annual Report, states:

"In the lower foothills in Madera and Mariposa counties is a belt of mica-schist, portions of which carry large andalusite (or, more properly, chiastolite) crystals in great abundance. Attention was called to this schist belt many years ago by Prof. W. P. Blake. Andalusite crystals 3 inches or more in length and half an inch or more in diameter are abundant in mica schist at the Ne Plus Ultra Copper Mine on Daulton's Ranch, about 10 miles northeast of Berenda. The andalusite crystals weathered out from the schist are scattered over the surface of the ground. A bed of almost horizontally bedded conglomerate, probably of miocene age, that caps a schist hill, perhaps 2 miles northwest of Daulton's, contains numerous andalusite crystals. This mica-schist belt at Daulton's is about 2 miles wide; further north, on the Chowchilla River, the width is perhaps 4 miles.. Andalusite schists have been formed, as above noted, from the clay-slates of the Mariposa beds west of Mariposa, and it is considered possible that the schists above described represent the south end of the western belt of the Mariposa formation. The general strike of this belt of clay-slates would carry it into the Chowchilla mica-andalusite-schist area."



Champion Andalusite Mine. View showing sorting patio and sacked ore ready for pack train. Champion Porcelain Company, Shealy, Mono County.

None of this material has been utilized commercially.

Bibl: California State Mining Bureau Bull. 91, pp. 182–183.

Andalusite has been reported as occurring along the wall of a quartz vein in the Sebastopol (formerly Hart) Mine in Sec. 32, T. 5 S., R. 19 E., 1½ miles southwest of Bootjack.

Mono County.

Champion Sillimanite, Inc.; Dr. J. A. Jeffrey, president; B. A. Jeffrey, secretary; Charles D. Woodhouse, general manager. Home office: Detroit, Michigan. Local office: Mocalno, California.

The deposit owned by this company is the largest known deposit of andalusite in the United States. It is located on the north side of Dry Creek Canyon, on the northwest slope of the White Mountains, of the Inyo Range, 7 miles east of Shealy, a station on the California and Nevada Railroad. Elevation 7500′ to 10,000′. Holdings comprise 10 claims.

[1] Turner, H. W. The rocks of the Sierra Nevada, U. S. Geol. Survey, Fourteenth Annual Report, Part 2, pp. 455–456.

The country rock in the vicinity of the deposit consists largely of argillite, more or less slaty, and schistose conglomerate. The conglomerates are composed mainly of fragments of fine-grained quartzite. There are two prominent outcrops of andalusite rock more or less parallel, which have a general northerly strike.

The most westerly deposit of andalusite is located at an elevation of 7500′ and is more than 300′ wide and about 500′ in length and extends to a depth of 300′. Veins and stringers of quartz penetrate the andalusite mass for long distances. The narrow stringers of quartz carry considerable quantities of the deep-blue mineral, lazulite. Muscovite is also common in the quartz. Andalusite rock consisting wholly of coarsely-granular andalusite and free from quartz stringers, occurs on the northwest side of the deposit. This deposit is of lower grade than the upper deposit, but it is being developed by tunnel. The

Andalusite mass. View showing workings on east face of outcrop. Champion Porcelain Company, White Mountains, Mono County.

material mined will be utilized in the manufacture of various ceramic materials, for the electrical insulator trade and including super-refractories, together with a line of refractory brick.

The upper deposit which occurs at an elevation of 10,000′, and approximately one mile east, is a massive outcrop, about 300′ wide and 600′ in length and extends to a depth of over 300′.

The rock to the west of the deposit is a schistose volcanic porphyry, while to the east is granite.

The andalusite occurs along the east face of this massive outcrop of quartzite and also as irregular stringers and lenses in the quartzite. The ore mined carries from 70% to 75% andalusite. The other minerals contained are pyrophylite, muscovite, lazurite, corundum, rutile and lazulite.

Mining operations were started on this deposit in 1921 and it has been a steady producer to date. Development consists of a tunnel

driven west nearly through the quartzite, with laterals driven north and south along ore showings in the quartzite.

The ore is mined by the open stope and pillar method. The ore trammed from workings is first broken by hand and sorted to a size of 4″ to 6″ in diameter. The selection of the material is based on frequent specific gravity tests by means of a Jolly balance. The selected ore is sacked to 100 pounds for packing by pack-train to the loading camp, a distance of 4 miles by trail. It is then hauled by truck a distance of 3½ miles to Shealy siding, on the railroad, for shipment to Detroit, Michigan, where it is utilized in the manufacture of porcelain for automobile spark plugs and other high tension electrical insulators.

At Shealy siding concrete floors have been built that have a ground storage capacity of 2500 tons. The material is stored here and shipped according to the tonnage required at the company's plant at Detroit. The production amounts to 150 tons per month. Fifteen men are employed.

Equipment: Electric power is secured from a hydroelectric plant located on the Jeffrey ranch at Shealy. The capacity of the plant is 225 h.p. The transmission line from the plant to the mine is 5 miles in length. There are two compressor plants on the property; one at the upper deposit and the other at the lower deposit; air drills and houses for employees at both camps.

Bibl: State Mineralogist's Reports XX, pp. 149–154; XXII, pp. 400–401. Journal, Washington Academy of Science, 1917, by Adolph Knopf, of U.S.G.S.; 'An Andalusite Mass in the pre-Cambrian of Inyo Range.' U. S. Bureau of Mines, I. C. 6255. See also special article on this deposit by Dr. Jeffrey and Mr. Woodhouse elsewhere herein (*post*) especially written for this present report.

Nevada County.

Andalusite is a constituent of quartzite at Grass Valley.

Bibl: Lindgren, W., 'The Gold Quartz Veins of Nevada City and Grass Valley'; 17th Annual Rept. U. S. Geol. Survey 1895–96, Part 2; Cal. State Min. Bur. Bull 91, pp. 182–183.

Riverside County.

Large crystals of pink andalusite are found near Coahuila.

Bibl: Kunz, G. A., Gems of California, Cal. State Mining Bureau Bull. 37, p. 98.

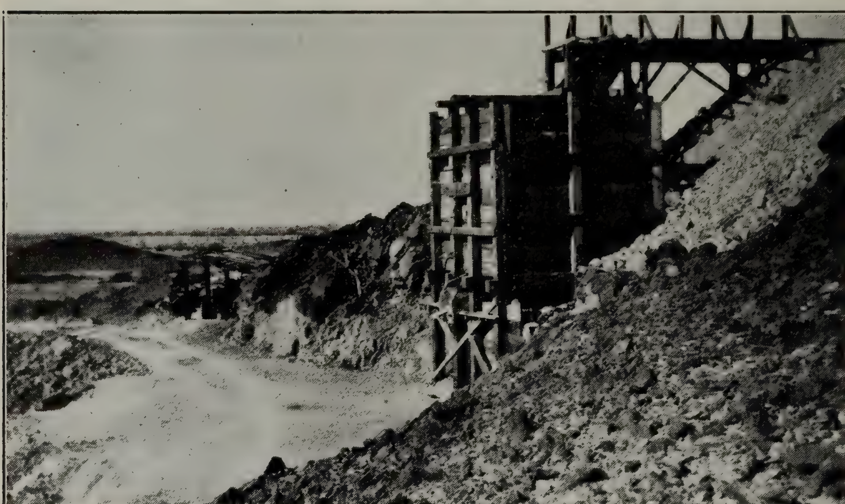
CYANITE

Imperial County.

Ogilby Cyanite Deposits. The deposits of cyanite occur near the base of the hills on the western slope of the Cargo Muchacho range of mountains, three miles northeast of Ogilby, a station on the Southern Pacific Railroad. Elevation 500′. Holdings comprise 10 claims known as the Drifted Snow and Blue Bird groups, totaling 200 acres. Owner, *Vitrefrax Corporation,* 5050 Pacific Boulevard, Los Angeles; R. H. Shainwald, president; T. S. Curtis, vice president; C. B. Knemeyer, secretary; James Neese, plant superintendent; C. O. Newton, mine superintendent.

The first discovery of cyanite was made in a low, rounded hill, one-eighth mile wide by one-half mile in length and probably consists of 25% cyanite in a matrix of quartz. One-quarter of a mile further east, a prominent vein of cyanite outcrops for one-half a mile in length. The vein which occurs in a mica schist, is nearly vertical

Main 'Blue Bird Quarry' of Vitrefrax Cyanite Mine, Ogilby, Imperial County.



Loading bin at cyanite mine of Vitrefrax Corporation, Ogilby, Imperial County.

and varies from 10′ to 200′ in width and strikes north. The most extensive showing has been found on the north end of the deposit on Blue Bird No. 2 Claim. Here it outcrops for over 200 feet in width.

The rock mined from this deposit consists of 40% cyanite in a matrix of quartz. On the Drifted Snow Claims, which are located on the south end of the deposit, both walls of the vein are pyrophyllite.

Here the cyanite occurs in a quartz gangue, with small amounts of black tourmaline occurring throughout the vein material.

Development consists of opencuts and tunnels made along the deposit on the different claims of the group. The ore at present being mined is from a quarry on the Blue Bird No. 2 Claim, this quarry being 300′ in height by 125′ in width by 200′ in to the face. The production amounts to 5000 to 6000 tons per year. The deposit is only worked during the winter months, when eight men are employed in getting out material for shipment to the company's plant at Los Angeles, where it is being used in the manufacture of high-grade refractories and is sold under the trade name of Vitrox.

Analysis of cyanite is as follows:

SiO_2	70%
Al_2O_3	28
Fe_2O_3, TeO_2, MgO, CaO, Alkalies	1.2
Ignition loss	0.8
Total	100.00%

Mine equipment consists of 125-cu ft. compressor, air drills and cars.

The mill at the company's plant in Los Angeles consists of 4 jaw crushers; 2 rolls; 6 ball mills; 3 magnetic separators; 5 25-foot dry and wet process kilns.

One hundred men are employed.

Bibl: State Mineralogist's Report XXII, pp. 269–270; Cal. State Division of Mines Bull. 99, p. 87; U. S. Bureau of Mines, I. C. 6255, March, 1930, pp. 13–14.

Los Angeles County.

Found in schists near Los Angeles.

Tuolumne County.

A constituent of the schists on Yankee Hill.

SILLIMANITE

A constituent of metamorphic gneiss and schist and occurs usually with cyanite, andalusite and staurolite.

Inyo County.

Random fibers of sillimanite in schist are found at the scheelite deposits in Deep Canyon, west of Bishop. Massive, near Laws.

Bibl: Calif. State Min. Bur. Bull. 91, p. 183.

Mariposa County.

Occurs in schists near Mariposa.

Bibl: Turner, H. W., Contributions to the Geology of the Sierra Nevada; 17th Ann. Rept. U. S. Geol. Sur. 1895, Part I, p. 529; Fairbanks, H. W., Geology of Mother Lode; 10th Ann. Rept. of State Mineralogist, 1890; Calif. State Min. Bur. Bull. 91, p. 183.

San Bernardino County.

Occurs in schist fifteen miles southeast of Daggett, at Ord Mountain.

Bibl: Calif. State Min. Bur. Bull. 91, p. 183.

San Diego County.

A constituent of the dumortierite gneiss at Dehesa.

Bibl: Shaller, W. T., Dumortierite, Amer. Jour. Sci., 1905; Calif. State Min. Bur. Bull. 91, p. 183.

A NOTE ON A DEPOSIT OF ANDALUSITE IN MONO COUNTY, CALIFORNIA; ITS OCCURRENCE AND TECHNICAL IMPORTANCE

By Dr. J. A. Jeffery and C. D. Woodhouse

Located at an altitude of 10,000′ above sea level on the western slope of the White Mountains in Mono County, California, the andalusite deposits of the Champion Sillimanite, Inc., present many new and unique characteristics from a geological as well as a mineralogical point of view. It is unquestionably the largest commercial deposit of this mineral in the known world today, a fact remarkable in itself when one considers the widespread occurrence of andalusite as a constituent of certain metamorphic rocks everywhere. Unusual color combinations, new crystal forms and a great variety of associated minerals found at this mine offer wide fields for intensive research in the realm of both crystallography and petrography. Andalusite is not a recent discovery among the minerals of the earth's crust as it was first found and identified about the year 1789 in the neighborhood of Forez, located in the province of Andalusia, Spain, from which it received its name. It has also been noted in Minas Geraes, Brazil; the Tyrolian Alps; Cumberland, England, and in the United States at various localities in Massachusetts, Pennsylvania, South Dakota, Arizona, Nevada, and California, but nowhere in quantities sufficient to warrant commercial exploitation. In 1913 Dr. Adolph Knopf reported the presence of andalusite in the White Mountain district during his investigation of a lazulite vein which was believed by prospectors to be a deposit of silver bromide (Jour. Wash. Acad. Sci. 1917, 7, 549). In 1920 Dr. J. A. Jeffery, President of the Champion Porcelain Company of Detroit, realizing the great superiority of the natural aluminum silicate over the artificial products in the ceramic industry, set out to look over the area described by Dr. Knopf with the hope of finding sufficient ore for commercial purposes. After some days spent in searching this area and finding nothing but low-grade outcrops, his patience and diligence were rewarded by finding a single piece of high-grade ore at the foot of the great cliff which forms the hanging wall of the main vein. Forcing his way up a steep gorge cut on the east side of the cliff, he finally located the immense mass of high-grade ore from which the float had come high up on the east face of an almost vertical rock-face. It was at the northern extremity of this outcrop that the first mining operations were started, the miners cutting a narrow trail through the solid rock to reach the ore. Once opened up, it became apparent that instead of isolated outcrops of this mineral, an immense zone of ore existed which would insure sufficient material for many years to come.

GEOLOGY

The Inyo Range, of which the White Mountains form the northern portion, began to assume its present form at the close of the Jurassic, at which time the sedimentaries were folded and intruded by granodiorites and quartz monzonites. From this period until the

close of the Tertiary, the range was subjected to intensive faulting and further instrusions of plutonic rocks and it is probable that at the close of this period the mountains had assumed their present topographic structure. The section of the range where the mine of the Champion Sillimanite, Inc., is situated, is composed largely of pre-Cambrian metamorphics, notably shales, conglomerates, quartzites and highly-aluminous schists, the latter being in contact with the ore in

View of cliffs looking east at andalusite deposit of Champion Sillimanite, Inc., Mono County.

many places. Granite, probably Cretaceous in age, comes in contact with the schist near the zones of ore deposition. The striking feature of the topography of the deposit is the hugh outcrop of iron-stained quartzite which, by reason of its resistance to erosion, towers above the surrounding surface. This mass forms both the hanging and the foot wall of the vein which nearly bisects its entire length. It is believed that the andalusite was formed by contact metamorphic action at moderate temperatures between the granite and granodiorite and sedimentaries rich in alumina, such as bauxitic clays which were formed as the result of sedimentary deposition in Archean time and now exist as a white talcose shale showing a marked schistosity. This theory of the formation of andalusite in the present instance is further borne out by the presence of rutile, potash, and magnesia which are always present in clays of this character. Microscopic study of the quartzite cliff reveals the presence of rounded grains of sand and there are no signs of any phenocysts of feldspar which would identify it as a keratophyre and, as such, might have been the probable source of the alumina.

THE DEPOSIT

The zone in which the andalusite occurs is roughly two miles long and thirty feet wide, being covered by nine claims, seven of which are patented. Its strike is NNW. and its dip from 75° to 80° SE. Both the hanging and the foot wall are quartzite except in certain portions

where the latter wall is formed of a white talcose shale, badly eroded and containing a large percentage of damourite. The main vein shows many fissures perpendicular to its strike which are filled with white, barren quartz, these probably being derived from the last stages of the granitic magma. The ore itself is bluish gray in color which may be due to the presence of titanium in solid solution. In vugs in the high-grade ore, are many groups of parallel crystals whose terminations appear to show a different crystal habit than heretofore noted, the nearly square prisms of the conventional crystal form of andalusite being flattened in the direction of the macroaxis. There are very interesting associations of minerals found in connection with the andalusite; among those noted being pyrite, topaz, muscovite, damourite, lazulite, corundum, zircon, jarosite, native sulphur, fluorite, pyrophyllite, hematite, quartz, limonite, and rutile, the last-named mineral comprising between 2% and 3% of the ore. With the exception of the high-grade lenses, it is interesting to note that the quality of the ore is fairly constant throughout the total extent of the vein, its specific gravity averaging between 3.01 and 3.06. At a point about half way between the north and the south extremities of the deposit, a type of andalusite is found which differs markedly in both color and chemical composition from the main orebody. This species is found in long, green crystals arranged in fan-like aggregates in a matrix of white quartz and is noteworthy in that it is almost chemically pure, only traces of iron oxide being present. It is from this type of ore that the finest chemical ware is made.

East side of cliff showing mine workings, Champion Sillimanite, Inc., Mono County.

MINING METHODS

Due to the fact that the great bulk of the andalusite is either exposed or close to the surface, no difficult mining problems are present. The ore is either quarried or stoped according to its position and no timber is needed, as the country is remarkably hard and shows no

tendency to cave or slough off. Thirty per cent dynamite is used in order that the ore may be broken in large blocks, as it is important that manual breaking be used as far as possible so that such impurities as quartz and pyrite may be eliminated. The sorted ore is then arranged in piles containing about five tons and an average sample of the whole mass is taken. This sample, consisting of pieces about one-half inch square, is carefully weighed on a Jolly Balance to determine its specific gravity which is kept within strict limits. By this procedure, a careful check may be kept on the quality of the ore, as its specific gravity bears a direct relationship to the amount of impurities present. All ore passing the required tests is then sacked in ninety-five pound bags and packed on mules down a steep mountain trail for three and one-half miles to the foot of the mountain where it is loaded on a truck and taken to the storage pile at Shealy for shipment by rail, as needed, to the factory in Detroit, Michigan. The equipment at the mine consists of an office with guest rooms, bunk house, boarding house, machine shop, and compressor room. All machinery is electrically driven, power being furnished by a 187-k.v.a. hydroelectric unit. Abundant water for all purposes is piped by gravity from a spring one mile above the mine. All supplies must be transported to the mine on mule back, as the topography of the country prohibits any attempt to build a truck road farther than the foot of the mountain.

PLANT PROCESSES

Andalusite is employed in the manufacture of high-grade porcelain, such as is used in spark-plug cores and chemical ware. For these purposes the ore is first passed through rock breakers of the Blake and Dodge type, where it is reduced to minus one-half inch, then through Hardinge conical ball mills charged with three- and five-inch hammered-steel balls. The product from these mills is then passed over a magnetic separator to remove all metallic iron from the abraded balls and mill linings. The ore is then further reduced in Hardinge Pebble Mills to pass a thirty-mesh magnetically-vibrated screen and stored in bins. The minus thirty-mesh andalusite is then weighed in two-ton charges and loaded into 6 by 10-foot Abbe′ Pebble Mills charged with five tons of three-quarters inch to inch and one-half balls made of andalusite porcelain, water being added to make a thin cream-like paste and the mills are revolved at the speed of sixteen r.p.m. for nineteen and one-half hours, thus reducing the ore to minus 350-mesh. The mills are then opened and water, sufficient kaolin and ball-clay added to the ground andalusite to give it the proper characteristics for filter pressing and blank forming operations in case it is to be used for spark-plug cores, or casting if to be employed for such shapes as laboratory chemical ware. After this addition of the clays, the mills are revolved for a period of two hours to blend the charge thoroughly. Filter-pressing reduces the moisture content to about 30 per cent and the andalusite and clay mass, known as the 'body,' is stored in 20,000-pound batches for ten days to 'age' it and at the same time allow the process laboratory to form a number of samples, burn them and give the finished product all standard tests before the batch is released for production.

After a batch is released for production it is passed through two large pug mills and formed into rolls about eight inches in diameter and three feet long; these are piled on zinc or copper-covered steel platforms and taken to the blank-forming department. The blanks are formed in vertical-barreled pug mills but extruded through a die by a series of horizontal helixes. In the center of the die is located a so-called spindle which forms a central bore in the blank of such size that, after allowance has been made for drying and burning shrinkage, it will just accommodate the central electrode or spark-plug wire when assembled into the complete spark plug. The pugged blanks which are usually three to four inches in length and about one and one-quarter inches in diameter are placed on perforated metal trays and passed through a continuous dryer where the moisture content is slowly reduced from about 30 per cent to less than 1 per cent. The bone-dry blanks are then mounted on stationary centers and brought against the face of carborundum or alundum wheels which have been dressed by means of diamond-pointed tools, to give the blanks the desired shape or form. The forming machines are so designed that the tolerances are readily maintained within .003 of an inch plus or minus.

The formed pieces are now mounted on vertical-revolving spindles of a spraying machine and coated with glaze. This is composed of suitable silicates that have been melted into a glass and ground in pebble mills to pass 350-mesh, enough water being added to make a thin cream-like mixture. The composition of this glaze is of extreme importance as it must fuse to a smooth glass at the maturing temperature of the porcelain body and its coefficient of expansion must coincide with that of the porcelain to avoid any strains when the finished piece is subjected to temperatures as high as 2000° F. Such a glaze adds materially to the tensile strength of the porcelain, as well as to its ability to resist sudden shock.

After the spraying, the pieces are stood on end in saggers (crucible-like containers made of refractory andalusite grain as hereinafter described) and passed through a Dressler Tunnel Kiln which reaches a maximum temperature of 2700° F. The burning or firing operation is not only carefully controlled as to temperature but the atmosphere in the tunnel must be accurately controlled at the entrance. There must be in excess of 14 per cent of CO_2 and a trace or up to 1 per cent of CO. Then, as the ware reaches the high-temperature zone the CO_2 content is gradually reduced until at the end of the zone it is lowered to 1 per cent. The atmosphere of the tunnel is controlled by twelve recording CO_2 meters that draw the gases from the tunnel at suitable points. Any deviations from standard conditions are immediately corrected by the operator by the setting or timing of the pumps that inject minute, intermittent streams of oil into the kiln tunnel. The control of the atmosphere in the tunnel within the prescribed limits would not be possible if it were not for the fact that the products of combustion from the main burners are drawn off through chambers in each side of the tunnel and do not mingle with the saggers or ware.

It requires seventy-two hours for the passage of the ware through the kiln, the cars carrying the saggers moving at a uniform rate of speed throughout the entire length of the tunnel. The spark-plug porcelains are now marked with the name, 'Champion,' in red letters, given a final

microscopic inspection for minute defects, packed in wooden boxes and shipped to the main plant of the Champion Spark Plug Co., at Toledo, Ohio; the Champion Porcelain Co. and the Champion Sillimanite, Inc., being subsidiaries of this company.

TECHNICAL IMPORTANCE

Porcelains made from andalusite are notable for their great tensile strength, this being from three to five times that of ordinary electrical porcelain, their ability to resist sudden changes of temperature and their high electrical resistivity at elevated temperatures. When employed in the manufacture of pyrometer tubes, andalusite not only retains its shape at high temperatures but greatly lengthens the life of the rare-metal thermocouple by excluding injurious gases, such as CO. It is not unusual for couples to remain in constant service for a year or more while the life in an ordinary tube is but a few weeks.

Refractory shapes made of andalusite grains of properly selected sizes have remarkable load-sustaining properties up to 3250° F. and can be substituted for silicon carbide and fused alumina to great advantage in continuous or tunnel kilns employed in the porcelain and steel-annealing industries. Andalusite grain mixed with a small portion of refractory clay and just enough water to make a stiff plastic mass is widely used in tilting-arc furnaces. A mass of this mixture about half the size of a man's head can be rammed into place while the furnace is in operation and without interfering with production, thus increasing the life of the lining from a few hundred to over two thousand heats. Unike all refractory-clay shapes, andalusite refractories do not change their dimensions in burning, the burned size being exactly that of the molded shape. This property is extremely important where accurate fitting of parts is desirable or necessary.

In conclusion, it is important to note that all the members of the sillimanite group; andalusite, sillimanite and cyanite, invert to mullite ($Al_6Si_2O_{13}$) at temperatures ranging from 2185° to 2650° F., the inversion point being directly influenced by the grain sizes and the time of heating.

ESTABLISHMENT OF TRINITY AND KLAMATH RIVER FISH AND GAME DISTRICT AFFECTS MINING

Senate Bill No. 286, introduced at the 1931 session of the Legislature, was passed, and approved by the Governor on April 24, 1931. This act will affect placer mining operations on certain portions of these rivers during three months of each year.

The text of the law, which becomes effective August 14, 1931, follows:

SENATE BILL NO. 286—CHAPTER 215

An act to create the Trinity and Klamath river fish and game district, and to prohibit, to provide penalties for, and to declare a public nuisance the mudding, roiling and polluting of the waters of said district.

[Approved by the Governor April 24, 1931.]

The people of the State of California do enact as follows:

SECTION 1. For the protection, conservation and propagation of the fish, and to secure the enjoyment of the right of the people to fish, in certain streams during a certain season each year, there is hereby set apart and established a district to be known as the ''Trinity and Klamath river fish and game district'' which shall consist of the following:

The Klamath river and the waters thereof, following its meanderings from the mouth of the Klamath river in Del Norte county to its confluence with the Salmon river, and also the Trinity river and the waters thereof, following its meanderings from its confluence with the Klamath river in the county of Humboldt to its confluence with the south fork of the said Trinity river.

SEC. 2. Every person, firm, association or corporation, who, between the fifteenth day of July and the fifteenth day of October of any year, pollutes, muddies, or roils any of the waters of the said Trinity and Klamath river fish and game district or any of the streams therein so as to affect the clarity thereof within the limits of said district for a distance of one mile, or more, or who permits, places, deposits, or dumps any debris, mud, gravel, dirt or other substance into any of the said waters or streams in said district, that will pollute, muddy, roil or cause to pollute, muddy or roil any of the waters or streams therein so as to affect the clarity thereof within the limits of said district for a distance of one mile, or more, is guilty of a misdemeanor.

SEC. 3. Any muddying, polluting or roiling of said waters or placing, depositing or dumping any debris, mud, gravel, dirt or other substance into any of said waters or into any of said streams that will pollute, muddy or roil any of said waters or any of said streams so as to affect the clarity thereof within the limits of said district for a distance of one mile, or more, between the fifteenth day of July and

the fifteenth day of October of any year is hereby declared to be a public nuisance.

Sec. 4. The general provisions of the laws of this state which are now in effect or which shall hereafter be enacted as to any or all of the fish and game districts as now existing or hereafter changed, and included in whole or in part within the territorial limits or waters of said Trinity and Klamath river fish and game district, herein created, shall apply as to the lands and waters thereof respectively within said Trinity and Klamath river fish and game district, except as herein provided.

Sec. 5. The provisions hereof shall not apply to the construction, repair or maintenance of public works by the federal or state government or any political subdivision thereof.

Sec. 6. The clarity of the waters of said district shall not be deemed to be affected within the meaning of this act until said waters contain more than fifty parts per million, by weight, of suspended matter; nor shall any person, firm or corporation be prosecuted under the provisions of this act for any activity engaged in or thing done between the fifteenth day of October of any year and the fifteenth day of July of the succeeding year.

U. S. MINT AIDS PROSPECTORS

State Mineralogist, Walter W. Bradley, has been advised by Mr. M. J. Kelly, Superintendent of the Mint, at San Francisco, that the Mint now accepts gold in quantities of 2 ounces and over.

The rules and regulations governing the U. S. Mints state that a deposit must be of $100 value before it can be received, but prior to 1926, deposits of $50 value were accepted at the San Francisco Mint. In 1926 orders came from Washington to adhere to the $100 rule, and this order has been enforced until this year, when, on June 2d, the Director of the Mint authorized the Superintendent at San Francisco to accept deposits of gold in quantities of 2 ounces or over. The order applies only to gold in the natural state, and not to dental or jewelry scrap, or other fabricated material.

This permission has been granted for the purpose of giving encouragement to small-scale placer mining during the present season only, and is not permanent.

ADMINISTRATIVE

WALTER W. BRADLEY, State Mineralogist

Personnel.

There have been no changes nor additions of personnel to be noted during the past three months.

Appropriations.

The appropriations allotted by the recent session of the legislature in the budget for the 83d–84th fiscal years (July 1, 1931–June 30, 1933), totaled $136,500 for the developmental survey activities of the division of mines, and $22,000 for the special item of the 'geological survey.' It had been our hope and the hope of those interested in the progress of the geological and economic minerals survey which is so important fundamentally to the economic development of California's mineral resources, that a larger allotment would be made to this work. A special appropriation bill was introduced in the Assembly (A. B. 1217) to provide the sum of $75,000. It received the approval of the administration, and passed the lower house without opposition; but was lost in the Senate in the last-minute rush of the closing hours by being tabled wholesale in the Finance Committee along with a number of proposed salary raises of certain State officers. The $22,000 provided in the budget for geological work will keep that program alive, but will not permit of material expansion during the ensuing two years.

New Publications.

MINING IN CALIFORNIA (quarterly), January, 1931, being Chapter I, of the State Mineralogist's Report XXVII. Price 25 cents. Contains: "Preliminary Report on Economic Geology of Shasta Quadrangle"; and special articles on: "Beryllium and Beryl," "The New Tariff and Nonmetallic Products," "Crystalline Talc," "Decorative Effects in Concrete."

Commercial Mineral Notes, Nos. 97, 98, 99, April, May, June, 1931, respectively. These 'notes' contain the lists of 'mineral deposits wanted' and 'mineral deposits for sale,' issued in the form of a mimeographed sheet, monthly. It is mailed free to those on the mailing list for MINING IN CALIFORNIA. As an evidence of the interest in mines and minerals now showing considerable activity, this mimeographed 'sheet' has had to be expanded to two pages for the current issues.

Mails and Files

The Division of Mines maintains, in addition to its correspondence files and library, a mine file which includes original reports on the various mines and mineral properties of all kinds in California.

During each quarterly period there are several thousand letters received and answered at the San Francisco office alone, covering almost every phase of prospecting, mining and developing mineral deposits, reduction problems, marketing of refined products, and mining law. In addition to this, hundreds of oral questions are answered daily, both at the main office and the district offices, for the many inquirers who come in for personal interviews and to consult the files and library.

MINERALS AND STATISTICS

Statistics, Museum, Laboratory

HENRY H. SYMONS, Statistician and Curator

STATISTICS

The total value for the mineral output for California for the year 1930 was $365,604,695, being a decrease of $66,643,533 from the 1929 total of $432,248,228. There were fifty-one different mineral substances, exclusive of a segregation of the various stones grouped under gems; and all but one of the fifty-eight counties of the State contributed to the list.

As revealed by the data following, the salient features of 1930 compared with the previous year were: A material decline in the amount and value of the petroleum output, with notable decreases in amounts and values of cement, natural gas, copper, miscellaneous stone, salt, brick and hollow building tile, and pottery clay. Increases were registered by gold, mineral water, borax, potash, quicksilver, lime, and lead. Petroleum showed a decrease in value of $49,667,817. There was a decrease from 292,534,221 barrels to 227,328,988. The 1929 output of crude oil was the largest in the history of the State and the decrease was due to curtailment in production rather than decreased prices. The natural gas output decreased from 400,129,201 M cu. ft. valued at $29,067,546 to 315,513,952 M cu. ft. worth $24,559,840.

Of the metals, the gold production increased in value from a total of 8,526,703 to $9,451,162; quicksilver from 10,152 flasks worth $1,195,705 to 11,374 flasks worth $1,255,257; and lead from 1,428,777 lbs. worth $90,014 to 3,524,796 lbs. worth $176,241. Decreases were shown in copper from 33,809,258 lbs. worth $5,941,799 to 26,534,752 lbs. worth $3,449,522, and silver from 1,176,895 fine oz. worth $627,285 to 1,622,803 fine oz. worth $624,779. The increase in gold was due to increased activity from the lode mines; the placer mines output showed a decrease charged entirely to the dredges. The decrease in copper was due to the declining price of the metal during the year.

Of the structural materials, lime was the only important item to show an increase, which was from 42,834 tons worth $417,101 to 47,662 tons worth $452,084. Cement decreased from 12,794,729 bbls. worth $21,038,565 to 9,831,938 bbls. worth $14,575,731, brick and hollow building tile from a value of $5,607,410 to $4,205,460 and miscellaneous stone from $17,840,159 to $16,430,027. Of the industrial minerals, mineral water showed an increase from 27,032,083 gals. worth $2,040,615 to 37,354,111 gals. worth $2,870,663; pumice and volcanic ash and fuller's earth also showed small increases in their total values, with all materials, other than these, in the group showing decreases and a decrease in total value. Of the saline group, borax showed increases from 144,687 tons worth $3,312,085 to 209,960 tons worth $3,686,817; potash also showed a marked increase, but not enough to offset the decrease in salt and

other minerals of this group. All groups showed a decrease in their totals of value.

The distribution of the 1930 output of California by substances is shown in the following tabulation:

Substance	*Amount*		*Value*
Barytes	19,783	tons	$133,107
Bituminous rock	8,525	tons	36,075
Borates	209,869	tons	3,686,817
Brick and hollow building tile	------		4,205,460
Cement	9,831,938	bbls.	14,575,731
Chromite	80	tons	1,905
Clay (pottery)	938,586	tons	795,517
Coal	10,885	tons	59,858
Copper	26,534,752	lbs.	3,449,522
Dolomite	35,721	tons	106,813
Feldspar	5,014	tons	35,654
Fuller's earth	12,522	tons	177,964
Gems	------		3,540
Gold	------		9,451,162
Granite	------		855,477
Gypsum	116,865	tons	243,507
Lead	3,524,796	lbs.	176,241
Lime	47,662	tons	452,084
Limestone	169,477	tons	508,751
Magnesite	38,681	tons	388,472
Marble (onyx and travertine)	------		82,194
Mineral water	37,354,111	gals.	2,870,663
Natural gas	315,513,952	M cu. ft.	24,559,840
Petroleum	227,328,988	bbls.	271,699,046
Platinum	217	fine oz.	11,700
Pumice and volcanic ash	12,947	tons	128,847
Pyrites	39,954	tons	194,228
Quicksilver	11,374	flasks	1,255,257
Salt	347,945	tons	1,167,487
Sandstone	------		56,404
Silica	17,802	tons	71,380
Silver	1,622,803	fine oz.	624,779
Soapstone and talc	15,861	tons	154,258
Soda	90,122	tons	1,627,344
Stone, miscellaneous [a]	------		16,430,027
Unapportioned [b]	------		5,327,584
Total value			$365,604,695

[a] Includes macadam, ballast, rubble, riprap, sand, and gravel.
[b] Includes asbestos, bromine, calcium chloride, diatomaceous earth, iron ore, magnesium salts, manganese or manganese ore, mineral paint, potash, slate, silimanite-andalusite-cyanite group, tube-mill pebbles, sulphur and tungsten, also paving blocks.

Distribution by counties is given in the following tabulation:

Alameda	$2,529,337
Alpine	2,500
Amador	2,424,687
Butte	539,666
Calaveras	2,083,956
Colusa	50,140
Contra Costa	1,643,286
Del Norte	176,030
El Dorado	493,243
Fresno	2,324,473
Glenn	61,179
Humboldt	270,633
Imperial	368,023
Inyo	2,260,766
Kern	42,987,977
Kings	13,106,843
Lake	268,364
Lassen	18,094
Los Angeles	171,616,329
Madera	675,782
Marin	405,541
Mariposa	143,465
Mendocino	123,062
Merced	801,900
Modoc	16,250
Mono	148,984
Monterey	452,974
Napa	532,983
Nevada	2,320,233
Orange	26,335,290
Placer	323,717
Plumas	3,219,900
Riverside	3,220,636
Sacramento	2,303,108
San Benito	1,389,490
San Bernardino	10,657,301
San Diego	1,303,047
San Francisco	23,428
San Joaquin	724,862
San Luis Obispo	248,115
San Mateo	2,499,937
Santa Barbara	24,368,374
Santa Clara	884,329
Santa Cruz	2,361,954
Shasta	1,111,146
Sierra	606,585
Siskiyou	235,401
Solano	46,638
Sonoma	330,399
Stanislaus	331,688
Sutter	------
Tehama	226,400
Trinity	437,333
Tulare	253,144
Tuolumne	318,322
Ventura	31,952,052
Yolo	27,000
Yuba	1,018,399
Total	$365,604,695

MUSEUM

The Museum of the State Division of Mines possesses an exceptionally fine collection of rocks and minerals of both economic and academic value. It ranks among the first five of such collections in North America and contains not only specimens of most of the known minerals found in California, but much valuable and interesting material from other states and foreign countries as well.

Mineral specimens suitable for exhibit purposes are solicited, and their donation will be appreciated by the State Division of Mines as well as by those who utilize the facilities of the collection.

The exhibit is daily visited by engineers, students, business men, and prospectors, as well as tourists and mere sightseers. Beside its practical use in the economic development of California's mineral resources, the collection is a most valuable educational asset to the State and to San Francisco.

LABORATORY

By Frank Sanborn, Mineral Technologist

Scheelite, a tungstate of calcium, is the chief tungsten mineral of this State. Important deposits occur in San Bernardino, Kern, and Inyo counties, and it has been found in Siskiyou, San Diego, and many counties between these north and south extremities.

Most of the scheelite occurrences reported by the Division of Mines are found in garnet rock. Prospectors should, therefore, carefully examine all garnet-bearing formations for the presence of tungsten.

Scheelite is usually of a white color, although sometimes yellowish and occasionally brownish. Its specific gravity is about 6 and the mineral can generally be obtained as a concentrate in panning.

If it is being sought, the material to be tested should be crushed and panned the same as for gold. Any heavy concentrates should be washed carefully into a small beaker or test tube and excess water decanted. A small amount of hydrochloric acid should next be added and the material boiled. A bright yellow-colored precipitate may be tungstic oxide. Add a small amount of tin (tinfoil will answer) and continue boiling. If scheelite is present the solution will turn blue and on continued boiling will turn brown. The blue color of this reaction is decisive, but under certain conditions, when the amount of tungsten present is very small, the blue color does not appear until the material has stood for about a half hour. It is advisable to allow the solution being tested to stand for a while before discarding.

A small egg pan, costing about ten cents, makes the best pan for prospecting purposes. If one of these pans full of dirt or crushed material does not show plainly gold or other minerals of value in the concentrates, further testing is not as a rule warranted. When rock in places is being tested, about a handful or double handful of the crushed rock should be used.

Instructions in panning are given to many who are not familiar with this method of concentrating gold, who call at the laboratory of the Division of Mines.

LIBRARY

HERBERT A. FRANKE, Librarian

In addition to the numerous standard works, authoritative information on many phases of the mining and mineral industry is constantly being issued in the form of reports and bulletins by various government agencies.

The library of the Division of Mines contains some five thousand selected volumes on mines, mining and allied subjects, and it is also a repository for reports and bulletins of the technical departments of federal and State governments and of educational institutions, both domestic and foreign.

It is not the dearth of the latter publications, but rather a lack of knowledge of just what has been published and where the reports may be consulted or obtained, that embarrasses the ordinary person seeking specific information.

To assist in making the public acquainted with this valuable source of current technical information, MINING IN CALIFORNIA contains under this heading a list of all books and official reports and bulletins received, with names of publishers or issuing departments.

Files of all the leading technical journals will be found in the library, and county and State maps, topographical sheets and geological folios. Current copies of local newspapers published in the mining centers of the State are available for reference.

The library and reading room are open to the public during the usual office hours, when the librarian may be freely called upon for all necessary assistance.

OFFICIAL PUBLICATIONS RECEIVED

Governmental.

U. S. Geological Survey:

Professional Papers:

165–D—Geology of the Big Snowy Mountains, Montana. By F. Reeves.
165–E—The Kaolin Minerals. By C. S. Ross and P. F. Kerr.

Bulletins:

818 —Geology and Mineral Resources of the Cleveland District, Ohio. By H. P. Cushing, Frank Leverett, and Frank R. van Horn.
819 —The Wasatch Plateau Coal Field, Utah. By Edmund M. Spieker.
821 —Contributions to Economic Geology: 1930. Part I—Metals and Nonmetals Except Fuels.
825 —Microscopic Determination of the Ore Minerals. By M. N. Short.

Water Supply Papers:

620 —Geology and Ground-Water Resources of Western Sandoval County, New Mexico. By B. C. Remick.
638–A—A Preliminary Report of the Artesian Water Supply of Memphis, Tenn.
641 —Part I. North Atlantic Slope Drainage Basins.
642 —Part II. South Atlantic Slope and Eastern Gulf of Mexico Basins.
643 —Part III. Ohio River Basin.

645 —Part V. Hudson Bay and Upper Mississippi River Basins.
654 —Part XII. North Pacific Slope Drainage Basin.
665 —Part IV. St. Lawrence River Basin.

United States Bureau of Mines:

Bulletins:

279 —Limits of Inflammability of Gases and Vapors. By H. F. Coward and G. W. Jones.
326 —Explosives Accidents in the Anthracite Mines of Pennsylvania. 1923–1927. By S. P. Howell.
335 —Quicksilver. By C. N. Schutte.
338 —Quarry Accidents in the U. S. During the Calendar Year 1929. By W. W. Adams.

Technical Papers:

496 —Accuracy of Manometry of Explosions. By C. M. Bouton, H. K. Griffin, and P. L. Golden.
497 —Electromagnetic Absorption by Rocks. By J. W. Joyce.
489 —Coal-mine Safety Organization in Alabama. By R. D. Currie.
490 —Separation and Size Distribution of Microscopic Particles. By P. S. Roller.
491 —Analyses of Washington Coals. By S. H. Ash.
492 —Deoxidation of Steel with Silicon. By C. H. Herty, Jr., G. R. Fitterer, and C. F. Christopher.
493 —Bibliography of United States Bureau of Mines Investigations on Coal and Its Products, 1910–1930. By A. C. Fieldner and M. W. von Bernewitz.
494 —Copper and Zinc in Cyanidation Sulphide Acid Precipitation. By E. S. Leaver and J. A. Woolf.
498 —II. Factors Governing the Entry of Solutions into Ores During Leaching. By J. D. Sullivan and E. O. Ostrea.

Mineral Resources of the United States:

Asphalt and Related Bitumens in 1929. By A. H. Redfield.
Bauxite and Aluminum in 1929. By C. E. Julian.
Cement in 1929. By B. W. Bagley.
Copper in 1929. By C. E. Julian and H. M. Meyer.
Fuel Briquets in 1930. By W. H. Young and J. M. Coise.
Gold, Silver, Copper, Lead, and Zinc in California and Oregon in 1929. By V. C. Heikes.
Gold, Silver, Copper, Lead, and Zinc in Nevada in 1929. By V. C. Heikes.
Gold, Silver, Copper, Lead, and Zinc in Idaho and Washington in 1929. By C. N. Gerry and T. H. Miller.
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For the convenience of persons wishing to consult the technical magazines in the reading room, a list of those on file is appended:

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Amador Dispatch, Jackson, California.
Barstow Printer, Barstow, California.
Beaumont Gazette, Beaumont, California.
Bridgeport Chronicle-Union, Bridgeport, California.
California Oil World, Los Angeles, California.
Calaveras Californian, Angels Camp, California.
Calaveras Prospect, San Andreas, California.
Colusa Daily Sun, Colusa, California.
Daily Commercial News, San Francisco, California.
Daily Midway Driller, Taft, California.
Del Norte Triplicate, Crescent City, California.
Denver Mining Record, Denver, Colorado.
Exeter Sun, Exeter, California.
Goldfield News, Goldfield, Nevada.
Inyo Independent, Independence, California.
Inyo Register, Bishop, California.
Ione Valley Echo, Ione, California.
Kettleman Oil and Gas News, Kettleman City, California.
Las Vegas Age, Las Vegas, Nevada.
Livermore Herald, Livermore, California.
Mariposa Gazette, Mariposa, California.
Mercury Register, Oroville, California.
Mojave Miner, Kingman, Arizona.
Mojave-Randsburg Record, Mojave, California.
Morning Union, Grass Valley, California.
Mountain Messenger, Downieville, California.
National Industrial Review, San Francisco, California.
Needles Nugget, Needles, California.
Nevada City Nugget, Nevada City, California.
Nevada Mining Press, Reno, Nevada.
Oil Refinery News, Bayonne, New Jersey.
Petroleum Press, Taft, California.
Placer Herald, Auburn, California.
Plumas Independent, Quincy, California.
San Diego News, San Diego, California.
Shasta Courier, Redding, California.
Siskiyou News, Yreka, California.
Sotoyome Scimitar, Healdsburg, California.
Stockton Record, Stockton, California.
Tehachapi News, Tehachapi, California.
Tuolumne Prospector, Tuolumne, California.
Ventura County News, Ventura, California.
Waterford News, Waterford, California.
Weekly Trinity Journal, Weaverville, California.
Western Mineral Survey, Salt Lake City, Utah.
Western Sentinel, Etna Mills, California.

PRODUCERS AND CONSUMERS

The producer and consumer of mineral products are mutually dependent upon each other for their prosperity, and one of the most direct aids rendered by the Bureau to the mining industry in the past has been that of bringing producers and consumers into direct touch with each other.

This work has been carried on largely by correspondence, supplemented by personal consultation. Lists of buyers of all the commercial minerals produced in California have been made available to producers upon request, and likewise the owners of undeveloped deposits of various minerals, and producers of them, have been made known to those looking for raw mineral products.

When the publication of Mining in California was on a monthly basis, current inquiries from buyers and sellers were summarized and lists of mineral products or deposits 'wanted' or 'for sale' included in each issue.

It is important that inquiries of this nature reach the mining public as soon as possible and in order to avoid the delay incident to the present quarterly publication of Mining in California, these lists are now issued monthly in the form of a mimeographed sheet under the title of 'Commercial Mineral Notes,' and sent to those on the mailing list for Mining in California.

EMPLOYMENT SERVICE

Following the establishment of the Mining Division branch offices in 1919, a free technical employment service was offered as a mutual aid to mine operators and technical men for the general benefit of the mineral industry.

Briefly summarized, men desiring positions are registered, the cards containing an outline of the applicant's qualifications, position wanted, salary desired, etc., and as notices of 'positions open' are received, the names and addresses of all applicants deemed qualified are sent to the prospective employer for direct negotiations.

Telephone and telegraphic communications are also given immediate attention.

Technical men, or those qualified for supervisory positions, and vacancies of like nature only, are registered, as no attempt will be made to supply common mine and mill labor.

Registration cards for the use of both prospective employers and employees may be obtained upon request, and a cordial invitation is extended to the industry to make free use of the facilities afforded. Parties interested should communicate direct with our San Francisco office.

PUBLICATIONS OF THE DIVISION OF MINES

During the past fifty-one years, in carrying out the provisions of the organic act creating the former California State Mining Bureau, there have been published many reports, bulletins and maps which go to make up a library of detailed information on the mineral industry of the State, a large part of which could not be duplicated from any other source.

One feature that has added to the popularity of the publications is that many of them have been distributed without cost to the public, and even the more elaborate ones have been sold at a price which barely covers the cost of printing.

Owing to the fact that funds for the advancing of the work of this department have often been limited, many of the reports and bulletins mentioned were printed in limited editions which are now entirely exhausted.

Copies of such publications are available, however, in the office of the Division of Mines, in the Ferry Building, San Francisco; Bankers Building, Los Angeles; State Office Building, Sacramento; Redding; Santa Maria; Santa Paula; Coalinga; Taft; Bakersfield. They may also be found in many public, private and technical libraries in California and other states, and foreign countries.

A catalog of all publications from 1880 to 1917, giving a synopsis of their contents, is issued as Bulletin No. 77.

Publications in stock may be obtained by addressing any of the above offices and enclosing the requisite amount in the case of publications that have a list price. Only coin, stamps or money orders should be sent, and it will be appreciated if remittance is made in this manner rather than by personal check.

The prices noted include delivery charges to all parts of the United States. Money orders should be made payable to the Division of Mines.

NOTE.—The Division of Mines frequently receives requests for some of the early Reports and Bulletins now out of print, and it will be appreciated if parties having such publications and wishing to dispose of them will advise this office.

REPORTS

Asterisks (**) indicate the publication is out of print.

	Price
**First Annual Report of the State Mineralogist, 1880, 43 pp. Henry G. Hanks	----
**Second Annual Report of the State Mineralogist, 1882, 514 pp., 4 illustrations, 1 map. Henry G. Hanks	----
**Third Annual Report of the State Mineralogist, 1883, 111 pp., 21 illustrations. Henry G. Hanks	----
**Fourth Annual Report of the State Mineralogist, 1884, 410 pp., 7 illustrations. Henry G. Hanks	----
**Fifth Annual Report of the State Mineralogist, 1885, 234 pp., 15 illustrations, 1 geological map. Henry G. Hanks	----
**Sixth Annual Report of the State Mineralogist, Part I, 1886, 145 pp., 3 illustrations, 1 map. Henry G. Hanks	----
**Part II, 1887, 222 pp., 36 illustrations. William Irelan, Jr.	----

REPORTS—Continued

Asterisks (**) indicate the publication is out of print.

	Price
**Seventh Annual Report of the State Mineralogist, 1887, 315 pp. William Irelan, Jr.	----
**Eighth Annual Report of the State Mineralogist, 1888, 948 pp., 122 illustrations. William Irelan, Jr.	----
**Ninth Annual Report of the State Mineralogist, 1889, 352 pp., 57 illustrations, 2 maps. William Irelan, Jr.	----
**Tenth Annual Report of the State Mineralogist, 1890, 983 pp., 179 illustrations, 10 maps. William Irelan, Jr.	----
Eleventh Report (First Biennial) of the State Mineralogist, for the two years ending September 15, 1892, 612 pp., 73 illustrations, 4 maps. William Irelan, Jr.	$1.00
**Twelfth Report (Second Biennial) of the State Mineralogist, for the two years ending September 15, 1894, 541 pp., 101 illustrations, 5 maps. J. J. Crawford	----
**Thirteenth Report (Third Biennial) of the State Mineralogist, for the two years ending September 15, 1896, 726 pp., 93 illustrations, 1 map. J. J. Crawford	----
Chapters of the State Mineralogist's Report, Biennial Period, 1913–1914, Fletcher Hamilton:	
**Mines and Mineral Resources, Amador, Calaveras and Tuolumne Counties, 172 pp., paper	----
Mines and Mineral Resources, Colusa, Glenn, Lake, Marin, Napa, Solano, Sonoma and Yolo Counties, 208 pp., paper	.50
**Mines and Mineral Resources, Del Norte, Humboldt and Mendocino Counties, 59 pp., paper	----
**Mines and Mineral Resources, Fresno, Kern, Kings, Madera, Mariposa, Merced, San Joaquin and Stanislaus Counties, 220 pages, paper	----
**Mines and Mineral Resources of Imperial and San Diego Counties, 113 pp., paper	----
**Mines and Mineral Resources, Shasta, Siskiyou and Trinity Counties, 180 pp., paper	----
**Fourteenth Report of the State Mineralogist, for the Biennial Period 1913–1914, Fletcher Hamilton, 1915:	
A General Report on the Mines and Mineral Resources of Amador, Calaveras, Tuolumne, Colusa, Glenn, Lake, Marin, Napa, Solano, Sonoma, Yolo, Del Norte, Humboldt, Mendocino, Fresno, Kern, Kings, Madera, Mariposa, Merced, San Joaquin, Stanislaus, San Diego, Imperial, Shasta, Siskiyou and Trinity Counties, 974 pp., 275 illustrations, cloth	----
Chapters of the State Mineralogist's Report, Biennial Period, 1915–1916. Fletcher Hamilton:	
**Mines and Mineral Resources, Alpine, Inyo and Mono Counties, 176 pp., paper	----
Mines and Mineral Resources, Butte, Lassen, Modoc, Sutter and Tehama Counties, 91 pp., paper	.50
**Mines and Mineral Resources, El Dorado, Placer, Sacramento and Yuba Counties, 198 pp., paper	----
Mines and Mineral Resources, Monterey, San Benito, San Luis Obispo, Santa Barbara and Ventura Counties, 183 pp., paper	.65
**Mines and Mineral Resources, Los Angeles, Orange and Riverside Counties, 136 pp., paper	----
**Mines and Mineral Resources, San Bernardino and Tulare Counties, 186 pp., paper	----
**Fifteenth Report of the State Mineralogist, for the Biennial Period 1915–1916, Fletcher Hamilton, 1917:	
A General Report on the Mines and Mineral Resources of Alpine, Inyo, Mono, Butte, Lassen, Modoc, Sutter, Tehama, Placer, Sacramento, Yuba, Los Angeles, Orange, Riverside, San Benito, San Luis Obispo, Santa Barbara, Ventura, San Bernardino and Tulare Counties, 990 pp., 413 illustrations, cloth	----
Chapters of the State Mineralogist's Report, Biennial Period 1917–1918, Fletcher Hamilton:	
Mines and Mineral Rosources of Nevada County, 270 pp., paper	.75
Mines and Mineral Resources of Plumas County, 188 pp., paper	.50
Mines and Mineral Resources of Sierra County, 144 pp., paper	.50

REPORTS—Continued

Asterisks (**) indicate the publication is out of print.

	Price
Seventeenth Report of the State Mineralogist, 1920, 'Mining in California during 1920,' Fletcher Hamilton; 562 pp., 71 illustrations, cloth	$1.75
Eighteenth Report of the State Mineralogist, 1922, 'Mining in California,' Fletcher Hamilton. Chapters published monthly beginning with January, 1922:	
**January, **February, **March, **April, **May, **June, **July, August, September, October, **November, December, 1922	Free
Chapters of Nineteenth Report of the State Mineralogist, 'Mining in California,' Fletcher Hamilton and Lloyd L. Root. January, February, March, September, 1923	Free
Chapters of Twentieth Report of the State Mineralogist, 'Mining in California,' Lloyd L. Root. Published quarterly. January, April, **July, October, 1924, per copy	.25
Chapters of Twenty-first Report of the State Mineralogist, 'Mining in California,' Lloyd L. Root. Published quarterly:	
January, 1925, Mines and Mineral Resources of Sacramento, Monterey and Orange Counties	.25
April, 1925, Mines and Mineral Resources of Calaveras, Merced, San Joaquin, Stanislaus and Ventura Counties	.25
July, 1925, Mines and Mineral Resources of Del Norte, Humboldt and San Diego Counties	.25
October, 1925, Mines and Mineral Resources of Siskiyou, San Luis Obispo and Santa Barbara Counties	.25
Chapters of Twenty-second Report of the State Mineralogist, 'Mining in California,' Lloyd L. Root. Published quarterly:	
January, 1926, Mines and Mineral Resources of Trinity and Santa Cruz Counties	.25
April, 1926, Mines and Mineral Resources of Shasta, San Benito and Imperial Counties	.25
July, 1926, Mines and Mineral Resources of Marin and Sonoma Counties	.25
October, 1926, Mines and Mineral Resources of El Dorado and Inyo Counties, also report on Minaret District, Madera County	.25
Chapters of Twenty-third Report of the State Mineralogist, 'Mining in California,' Lloyd L. Root. Published quarterly:	
January, 1927, Mines and Mineral Resources of Contra Costa County; Santa Catalina Island	.25
April, 1927, Mines and Mineral Resources of Amador and Solano Counties	.25
July, 1927, Mines and Mineral Resources of Placer and Los Angeles Counties	.25
October, 1927, Mines and Mineral Resources of Mono County	.25
Chapters of Twenty-fourth Report of the State Mineralogist, 'Mining in California,' Lloyd L. Root. Published quarterly:	
January, 1928, Mines and Mineral Resources of Tuolumne County	.25
April, 1928, Mines and Mineral Resources of Mariposa County	.25
**July 1928, Mines and Mineral Resources of Butte and Tehama Counties	----
October, 1928, Mines and Mineral Resources of Plumas and Madera Counties	.25
Chapters of Twenty-fifth Report of the State Mineralogist, 'Mining in California,' Walter W. Bradley. Published quarterly:	
January, 1929, Mines and Mineral Resources of Lassen, Modoc and Kern Counties; also on Special Placer Machines	.25
April, 1929, Mines and Mineral Resources of Sierra, Napa, San Francisco and San Mateo Counties	.25
July, 1929, Mines and Mineral Resources of Colusa, Fresno and Lake Counties	.25
October, 1929, Mines and Mineral Resources of Glenn, Alameda, Mendocino and Riverside Counties	.25
Chapters of Twenty-sixth Report of the State Mineralogist 'Mining in California', Walter W. Bradley. Published quarterly:	
January, 1930, Mines and Mineral Resources of Santa Clara County; also Barite in California	.25
April, 1930, Mines and Mineral Resources of Nevada County; also Mineral Paint Materials in California	.25
**July, 1930, Mines and Mineral Resources of Yuba and San Bernardino Counties; also Commercial Grinding Plants in California	----

REPORTS—Continued

Asterisks (**) indicate the publication is out of print.

	Price
October, 1930, Mines and Mineral Resources of Butte, Kings and Tulare Counties; also Geology of Southwestern Mono County (Preliminary)	$0.25
Chapters of Twenty-seventh Report of the State Mineralogist, 'Mining in California', Walter W. Bradley. Published quarterly:	
January, 1931, Preliminary Report on Economic Geology of the Shasta Quadrangle. Beryllium and Beryl. The New Tariff and Nonmetallic Products. Crystalline Talc. Decorative effects in Concrete	.25
April, 1931, Stratigraphy of the Kreyenhagen Shale. Diatoms and Silicoflagellates of the Kreyenhagen Shale. Foraminifer of the Kreyenhagen Shale. Geology of Santa Cruz Island	.25
Subscription, $1.00 in advance (by calendar year, only).	
Chapters of State Oil and Gas Supervisor's Report:	
Summary of Operations—California Oil Fields, July, 1918, to March, 1919 (one volume)	Free
Summary of Operations—California Oil Fields. Published monthly, beginning April, 1919:	
**April, **May, June, **July, **August, **September, **October, November, **December, 1919	Free
January, February, March, April, **May, June, July, **August, September, October, November, December, 1920	Free
January, **February, **March, **April, May, June, **July, August, **September, **October, **November, **December, 1921	Free
January, February, March, April, May, June, July, August, September, October, November, December, 1922	Free
January, February, March, April, May, June, July, August, September, October, November, December, 1923	Free
January, February, March, April, May, June, July, August, September, October, November, December, 1924	Free
January, February, March, April, May, June, July, August, September, October, November, December, 1925	Free
January, February, March, April, May, June, July, August, September, October, November, December, 1926	Free
January, February, March, April, May, June, July, August, September, October, November, December, 1927	Free
January, February, March, April, May, June, July, August, September, October, **November, **December, 1928	Free
January, February, March, April, May, June, July-August-September, October-November-December, 1929	Free
January-February-March, April-May-June, July-August-September, 1930 (Published quarterly beginning July, 1929.)	Free

BULLETINS

**Bulletin No. 1. A Description of Some Desiccated Human Remains, by Winslow Anderson. 1888, 41 pp., 6 illustrations	----
**Bulletin No. 2. Methods of Mine Timbering, by W. H. Storms. 1894, 58 pp., 75 illustrations	----
**Bulletin No. 3. Gas and Petroleum Yielding Formations of Central Valley of California, by W. L. Watts. 1894, 100 pp., 13 illustrations, 4 maps	----
**Bulletin No. 4. Catalogue of Californian Fossils, by J. G. Cooper, 1894, 73 pp., 67 illustrations. (Part I was published in the Seventh Annual Report of the State Mineralogist, 1887.)	----
**Bulletin No. 5. The Cyanide Process, 1894, by Dr. A. Scheidel. 140 pp., 46 illustrations	----
**Bulletin No. 6. California Gold Mill Practices, 1895, by E. B. Preston, 85 pp., 46 illustrations	----
**Bulletin No. 7. Mineral Production of California, by Counties, for the year 1894, by Charles G. Yale. Tabulated sheet	----
**Bulletin No. 8. Mineral Production of California, by Counties, for the year 1895, by Charles G. Yale. Tabulated sheet	----
**Bulletin No. 9. Mine Drainage, Pumps, etc., by Hans C. Behr. 1896, 210 pp., 206 illustrations	----
**Bulletin No. 10. A bibliography Relating to the Geology, Paleontology and Mineral Resources of California, by Anthony W. Vogdes. 1896, 121 pp.	----

BULLETINS—Continued

Asterisks (**) indicate the publication is out of print.

	Price
**Bulletin No. 11. Oil and Gas Yielding Formations of Los Angeles, Ventura and Santa Barbara Counties, by W. L. Watts. 1897, 94 pp., 6 maps, 31 illustrations	----
**Bulletin No. 12. Mineral Production of California, by Counties, for 1896, by Charles G. Yale. Tabulated sheet	----
**Bulletin No. 13. Mineral Production of California, by Counties, for 1897, by Charles G. Yale. Tabulated sheet	----
**Bulletin No. 14. Mineral Production of California, by Counties, for 1898, by Charles G. Yale	----
**Bulletin No. 15. Map of Oil City Fields, Fresno County, by John H. Means. 1899	----
**Bulletin No. 16. The Genesis of Petroleum and Asphaltum in California, by A. S. Cooper. 1899, 39 pp., 29 illustrations	----
**Bulletin No. 17. Mineral Production of California, by Counties, for 1899, by Charles G. Yale. Tabulated sheet	----
**Bulletin No. 18. Mother Lode Region of California, by W. H. Storms. 1900, 154 pp., 49 illustrations	----
**Bulletin No. 19. Oil and Gas Yielding Formations of California, by W. L. Watts. 1900, 236 pp., 60 illustrations, 8 maps	----
**Bulletin No. 20. Synopsis of General Report of State Mining Bureau, by W. L. Watts. 1901, 21 pp. This bulletin contains a brief statement of the progress of the mineral industry in California for the four years ending December, 1899	----
**Bulletin No. 21. Mineral Production of California by Counties, by Charles G. Yale. 1900. Tabulated sheet	----
**Bulletin No. 22. Mineral Production of California for Fourteen Years, by Charles G. Yale. 1900. Tabulated sheet	----
Bulletin No. 23. The Copper Resources of California, by P. C. DuBois, F. M. Anderson, J. H. Tibbits and G. A. Tweedy. 1902, 282 pp., 69 illustrations, 9 maps	$0.50
**Bulletin No. 24. The Saline Deposits of California, by G. E. Bailey. 1902, 216 pp., 99 illustrations, 5 maps	----
**Bulletin No. 25. Mineral Production of California, by Counties, for 1901, by Charles G. Yale. Tabulated sheet	----
**Bulletin No. 26. Mineral Production of California for the Past Fifteen Years, by Charles G. Yale. 1902. Tabulated sheet	----
**Bulletin No. 27. The Quicksilver Resources of California, by William Forstner. 1903, 273 pp., 144 illustrations, 8 maps	----
**Bulletin No. 28. Mineral Production of California for 1902, by Charles G. Yale. Tabulated sheet	----
**Bulletin No. 29. Mineral Production of California for Sixteen Years, by Charles G. Yale. 1903. Tabulated sheet	----
**Bulletin No. 30. Bibliography Relating to the Geology, Paleontology and Mineral Resources of California, by A. W. Vogdes. 1903, 290 pp.	----
**Bulletin No. 31. Chemical Analyses of California Petroleum, by H. N. Cooper. 1904. Tabulated sheet	----
**Bulletin No. 32. Production and Use of Petroleum in California, by Paul W. Prutzman. 1904, 230 pp., 116 illustrations, 14 maps	----
**Bulletin No. 33. Mineral Production of California, by Counties, for 1903, by Charles G. Yale. Tabulated sheet	----
**Bulletin No. 34. Mineral Production of California for Seventeen Years, by Charles G. Yale. 1904. Tabulated sheet	----
**Bulletin No. 35. Mines and Minerals of California, by Charles G. Yale. 1904, 55 pp., 20 county maps. Relief map of California	----
**Bulletin No. 36. Gold Dredging in California, by J. E. Doolittle. 1905. 120 pp., 66 illustrations, 3 maps	----
**Bulletin No. 37. Gems, Jewelers' Materials, and Ornamental Stones of California, by George F. Kunz. 1905, 168 pp., 54 illustrations	----
**Bulletin No. 38. Structural and Industrial Materials of California, by Wm. Forstner, T. C. Hopkins, C. Naramore and L. H. Eddy. 1906, 412 pp., 150 illustrations, 1 map	----
**Bulletin No. 39. Mineral Production of California, by Counties, for 1904, by Charles G. Yale. Tabulated sheet	----

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Asterisks (**) indicate the publication is out of print.

	Price
**Bulletin No. 40. Mineral Production of California for Eighteen Years, by Charles G. Yale. 1905. Tabulated sheet	----
**Bulletin No. 41. Mines and Minerals of California for 1904, by Charles G. Yale. 1905, 54 pp., 20 county maps	----
**Bulletin No. 42. Mineral Production of California, by Counties, 1905, by Charles G. Yale. Tabulated sheet	----
**Bulletin No. 43. Mineral Production of California for Nineteen Years, by Charles G. Yale. Tabulated sheet	----
**Bulletin No. 44. California Mines and Minerals for 1905, by Charles G. Yale. 1907, 31 pp., 20 county maps	----
**Bulletin No. 45. Auriferous Black Sands of California, by J. A. Edman. 1907. 10 pp.	----
**Bulletin No. 46. General Index of Publications of the California State Mining Bureau, by Charles G. Yale. 1907, 54 pp.	----
**Bulletin No. 47. Mineral Production of California, by Counties, 1906, by Charles G. Yale. Tabulated sheet	----
**Bulletin No. 48. Mineral Production of California for Twenty Years, by Charles G. Yale. 1906	----
**Bulletin No. 49. Mines and Minerals of California for 1906, by Charles G. Yale. 34 pp.	----
Bulletin No. 50. The Copper Resources of California, 1908, by A. Hausmann, J. Kruttschnitt, Jr., W. E. Thorne and J. A. Edman. 366 pp., 74 illustrations. (Revised edition.)	$1.00
**Bulletin No. 51. Mineral Production of California, by Counties, 1907, by D. H. Walker. Tabulated sheet	----
**Bulletin No. 52. Mineral Production of California for Twenty-one Years, by D. H. Walker. 1907. Tabulated sheet	----
**Bulletin No. 53. Mineral Production of California for 1907, with County Maps, by D. H. Walker. 62 pp.	----
**Bulletin No. 54. Mineral Production of California, by Counties, by D. H. Walker, 1908. Tabulated sheet	----
**Bulletin No. 55. Mineral Production of California for Twenty-two Years, by D. H. Walker, 1908. Tabulated sheet	----
**Bulletin No. 56. Mineral Production for 1908, with County Maps and Mining Laws of California, by D. H. Walker. 78 pp.	----
**Bulletin No. 57. Gold Dredging in California, by W. B. Winston and Chas. Janin. 1910, 312 pp., 239 illustrations, 10 maps	----
**Bulletin No. 58. Mineral Production of California, by Counties, by D. H. Walker. 1909. Tabulated sheet	----
**Bulletin No. 59. Mineral Production of California for Twenty-three Years, by D. H. Walker. 1909. Tabulated sheet	----
**Bulletin No. 60. Mineral Production for 1909, with County Maps and Mining Laws of California, by D. H. Walker. 94 pp.	----
**Bulletin No. 61. Mineral Production of California, by Counties, for 1910, by D. H. Walker. Tabulated sheet	----
**Bulletin No. 62. Mineral Production of California for Twenty-four Years, by D. H. Walker. 1910. Tabulated sheet	----
**Bulletin No. 63. Petroleum in Southern California, by P. W. Prutzman. 1912, 430 pp., 41 illustrations, 6 maps	----
**Bulletin No. 64. Mineral Production for 1911, by E. S. Boalich. 49 pp.	----
**Bulletin No. 65. Mineral Production for 1912, by E. S. Boalich. 64 pp.	----
**Bulletin No. 66. Mining Laws of the United States and California. 1914, 89 pp.	----
**Bulletin No. 67. Minerals of California, by Arthur S. Eakle. 1914, 226 pp.	----
**Bulletin No. 68. Mineral Production for 1913, with County Maps and Mining Laws, by E. S. Boalich. 160 pp.	----
**Bulletin No. 69. Petroleum Industry of California, with Folio of Maps (18 by 22), by R. P. McLaughlin and C. A. Waring. 1914, 519 pp., 13 illustrations, 83 figs. [18 plates in accompanying folio.]	----
**Bulletin No. 70. Mineral Production for 1914, with County Maps and Mining Laws. 184 pp.	----
**Bulletin No. 71. Mineral Production for 1915, with County Maps and Mining Laws, by Walter W. Bradley. 193 pp., 4 illustrations	----

BULLETINS—Continued

Asterisks (**) indicate the publication is out of print.

	Price
**Bulletin No. 72. The Geologic Formations of California, by James Perrin Smith. 1916, 47 pp.	----
**Reconnaissance Geologic Map (of which Bulletin 72 is explanatory), in 23 colors. Scale: 1 inch = 12 miles. Mounted	----
**Bulletin No. 73. First Annual Report of the State Oil and Gas Supervisor of California, for the Fiscal Year 1915–16, by R. P. McLaughlin. 278 pp., 26 illustrations	----
**Bulletin No. 74. Mineral Production of California in 1916, with County Maps, by Walter W. Bradley. 179 pp., 12 illustrations	----
**Bulletin No. 75. United States and California Mining Laws. 1917, 115 pp., paper	----
Bulletin No. 76. Manganese and Chromium in California, by Walter W. Bradley, Emile Huguenin, C. A. Logan, W. B. Tucker and C. A. Waring. 1918, 248 pp., 51 illustrations, 5 maps, paper	$0.50
Bulletin No. 77. Catalogue of Publications of California State Mining Bureau, 1880–1917, by E. S. Boalich. 44 pp., paper	Free
Bulletin No. 78. Quicksilver Resources of California, with a Section on Metallurgy and Ore-Dressing, by Walter W. Bradley, 1919, 389 pp., 77 photographs and 42 plates (colored and line cuts), cloth	1.50
Bulletin No. 79. Magnesite in California, by Walter W. Bradley. 1925, 147 pp., 62 photographs, 11 line cuts and maps, cloth	1.00
†Bulletin No. 80. Tungsten, Molybdenum and Vanadium in California. (In preparation.)	
†Bulletin No. 81. Foothill Copper Belt of California. (In preparation.)	
**Bulletin No. 82. Second Annual Report of the State Oil and Gas Supervisor, for the Fiscal Year 1916–1917, by R. P. McLaughlin. 1918, 412 pp., 31 illustrations, cloth	----
Bulletin No. 83. California Mineral Production for 1917, with County Maps, by Walter W. Bradley. 179 pp., paper	Free
**Bulletin No. 84. Third Annual Report of the State Oil and Gas Supervisor, for the Fiscal Year 1917–1918, by R. P. McLaughlin. 1918, 617 pp., 28 illustrations, cloth	----
**Bulletin No. 85. Platinum and Allied Metals in California, by C. A. Logan, 1919. 10 photographs, 4 plates, 120 pp., paper	----
Bulletin No. 86. California Mineral Production for 1918, with County Maps, by Walter W. Bradley. 1919, 212 pp., paper	Free
**Bulletin No. 87. Commercial Minerals of California, with notes on their uses, distribution, properties, ores, field tests, and preparation for market, by W. O. Castello. 1920, 124 pp., paper	----
Bulletin No. 88. California Mineral Production for 1919, with County Maps, by Walter W. Bradley. 1920, 204 pp., paper	Free
**Bulletin No. 89. Petroleum Resources of California, with Special Reference to Unproved Areas, by Lawrence Vander Leck. 1921, 12 figures, 6 photographs, 6 maps in pocket, 186 pp., cloth	----
Bulletin No. 90. California Mineral Production for 1920, with County Maps, by Walter W. Bradley. 1921, 218 pp., paper	Free
Bulletin No. 91. Minerals of California, by Arthur S. Eakle. 1923, 328 pp. cloth	1.00
Bulletin No. 92. Gold Placers of California, by Chas. S. Haley. 1923, 167 pp., 36 photographs and 7 plates (colored and line cuts, also geologic map), cloth	1.50
Extra copies of the Geologic Map (in 4 colors)	.50
Bulletin No. 93. California Mineral Production for 1922, by Walter W. Bradley. 1923, 188 pp., paper	Free
Bulletin No. 94. California Mineral Production for 1923, by Walter W. Bradley. 1924, 162 pp., paper	Free
Bulletin No. 95. Geology and Ore Deposits of the Randsburg Quadrangle, by Carlton D. Hulin. 1925, 152 pp., 49 photographs, 13 line cuts, 1 colored geologic map, cloth	2.00
**Bulletin No. 96. California Mineral Production for 1924, by Walter W. Bradley. 1925, 173 pp., paper	----
**Bulletin No. 97. California Mineral Production for 1925, by Walter W. Bradley. 1926, 172 pp., paper	----

† Not yet published.

BULLETINS—Continued

Asterisks (**) indicate the publication is out of print.

	Price
Bulletin No. 98. Mining Law (in press)	----
Bulletin No. 99. Clay Resources and Ceramic Industry of California, by Waldemar Fenn Dietrich. 1928, 383 pp., 70 photos, 12 line cuts including maps, cloth	$1.50
**Bulletin No. 100. California Mineral Production for 1926, by Walter W. Bradley. 1927, 174 pp., paper	----
**Bulletin No. 101. California Mineral Production for 1927, by Henry H. Symons. 1928, 311 pp., paper	----
Bulletin No. 102. California Mineral Production for 1928, by Henry H. Symons. 1929, 210 pp., paper	Free
Bulletin No. 103. California Mineral Production for 1929, by Henry Symons, 1930. 231 pp., paper	Free

PRELIMINARY REPORTS

**Preliminary Report No. 1. Notes on Damage by Water in California Oil Fields, December, 1913. By R. P. McLaughlin. 4 pp.	----
**Preliminary Report No. 2. Notes on Damage by Water in California Oil Fields, March, 1914. By R. P. McLaughlin. 4 pp.	----
Preliminary Report No. 3. Manganese and Chromium, 1917. By E. S. Boalich. 32 pp.	Free
**Preliminary Report No. 4. Tungsten, Molybdenum and Vanadium. By E. S. Boalich and W. O. Castello, 1918. 34 pp. Paper	----
**Preliminary Report No. 5. Antimony, Graphite, Nickel, Potash, Strontium and Tin. By E. S. Boalich and W. O. Castello, 1918. 44 pp. Paper.	----
Preliminary Report No. 6. A Review of Mining in California During 1919. By Fletcher Hamilton, 1920. 43 pp. Paper	Free
**Preliminary Report No. 7. The Clay Industry in California. By E. S. Boalich, W. O. Castello, E. Huguenin, C. A. Logan, and W. B. Tucker, 1920. 102 pp. 24 illustrations. Paper	----
**Preliminary Report No. 8. A Review of Mining in California During 1921, with Notes on the Outlook for 1922. By Fletcher Hamilton, 1922. 68 pp. Paper	----

MISCELLANEOUS PUBLICATIONS

**First Annual Catalogue of the State Museum of California, being the collection made by the State Mining Bureau during the year ending April 16, 1881. 350 pp.	----
**Catalogue of books, maps, lithographs, photographs, etc., in the library of the State Mining Bureau at San Francisco, May 15, 1884. 19 pp.	----
**Catalogue of the State Museum of California, Volume II, being the collection made by the State Mining Bureau from April 16, 1881, to May 5, 1884. 220 pp.	----
**Catalogue of the State Museum of California, Volume III, being the collection made by the State Mining Bureau from May 15, 1884, to March 31, 1887. 195 pp.	----
**Catalogue of the State Museum of California, Volume IV, being the collection made by the State Mining Bureau from March 30, 1887, to August 20, 1890. 261 pp.	----
**Catalogue of the Library of the California State Mining Bureau, September 1, 1892. 149 pp.	----
**Catalogue of West North American and Many Foreign Shells with Their Geographical Ranges, by J. G. Cooper. Printed for the State Mining Bureau, April, 1894	----
**Report of the Board of Trustees for the four years ending September, 1900. 15 pp. Paper.	----
Bulletin. Reconnaissance of the Colorado Desert Mining District. By Stephen Bowers, 1901. 19 pp. 2 illustrations. Paper.	Free
Commercial Mineral Notes. A monthly mimeographed sheet, beginning April, 1923	Free

MAPS

Register of Mines With Maps.

Asterisks (**) indicate the publication is out of print.

	Price
**Register of Mines, with Map, Amador County	----
**Register of Mines, with Map, Butte County	----
**Register of Mines, with Map, Calaveras County	----
**Register of Mines, with Map, El Dorado County	----
**Register of Mines, with Map, Inyo County	----
**Register of Mines, with Map, Kern County	----
**Register of Mines, with Map, Lake County	----
**Register of Mines, with Map, Mariposa County	----
**Register of Mines, with Map, Nevada County	----
**Register of Mines, with Map, Placer County	----
**Register of Mines, with Map, Plumas County	----
**Register of Mines, with Map, San Bernardino County	----
**Register of Mines, with Map, San Diego County	----
Register of Mines, with Map, Santa Barbara County (1906)	$0.25
**Register of Mines, with Map, Shasta County	----
**Register of Mines, with Map, Sierra County	----
**Register of Mines, with Map, Siskiyou County	----
**Register of Mines, with Map, Trinity County	----
**Register of Mines, with Map, Tuolumne County	----
Register of Mines, with Map, Yuba County (1905)	.25
Register of Oil Wells, with Map, Los Angeles City (1906)	.35

OTHER MAPS

**Map of California, Showing Mineral Deposits (50 x 60 in.)	----
**Map of Forest Reserves in California	----
**Mineral and Relief Map of California	----
**Map of El Dorado County, Showing Boundaries, National Forests	----
**Map of Madera County, Showing Boundaries, National Forests	----
**Map of Placer County, Showing Boundaries, National Forests	----
**Map of Shasta County, Showing Boundaries, National Forests	----
**Map of Sierra County, Showing Boundaries, National Forests	----
**Map of Siskiyou County, Showing Boundaries, National Forests	----
**Map of Tuolumne County, Showing Boundaries, National Forests	----
**Map of Mother Lode Region	----
**Map of Desert Region of Southern California	----
Map of Minaret District, Madera County	.20
Map of Copper Deposits in California	.05
**Map of Calaveras County	----
**Map of Plumas County	----
**Map of Trinity County	----
**Map of Tuolumne County	----
Geological Map of Inyo County. Scale 1 inch equals 4 miles	.60
**Map of California accompanying Bulletin No. 89, showing generalized classification of land with regard to oil possibilities. Map only, without Bulletin	----
Geological Map of California, 1916. Scale 1 inch equals 12 miles. As accurate and up-to-date as available data will permit as regards topography and geography. Shows railroads, highways, post offices and other towns. First geological map that has been available since 1892, and shows geology of entire state as no other map does. Geological details lithographed in 23 colors. Unmounted	.75
Mounted	2.00
Topographic Map of Sierra Nevada Gold Belt, showing distribution of auriferous gravels, accompanying Bulletin No. 92 (also sold singly) In 4 colors	.50

OIL FIELD MAPS

These maps are revised from time to time as development work advances and ownerships change.

	Price
Map No. 1—Sargent, Santa Clara County	$0.50
Map No. 2—Santa Maria, including Cat Canyon and Los Alamos	.75
Map No. 3—Santa Maria, including Casmalia and Lompoc	.75
Map No. 4—Whittier-Fullerton, including Olinda, Brea Canyon, Puente Hills, East Coyote and Richfield	.75
Map No. 5—Whittier-Fullerton, including Whittier, West Coyote and Montebello	.75
Map No. 6—Salt Lake, Los Angeles County	.75
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Map No. 8—South Midway and Buena Vista Hills, Kern County	.75
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Map No. 10—Belridge and McKittrick, Kern County	.75
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Map No. 17—Santa Paula-Sespe Oil Fields, Ventura County	.75
Map No. 18—Piru-Simi-Newhall Oil Fields	.75
Map No. 19—Arroyo Grande, San Luis Obispo County	.75
Map No. 20—Long Beach Oil Field	1.25
Map No. 21—Portion of District 4, Showing Boundaries of Oil Fields, Kern and Kings counties	.75
Map No. 21A—Portion Kern and Kings counties	.75
Map No. 22—Portion of District 3, Showing Oil Fields, Santa Barbara County	.75
Map No. 23—Portion of District 2, Showing Boundaries of Oil Fields, Ventura County	.75
Map No. 24—Portion of District 1, Showing Boundaries of Oil Fields, Los Angeles and Orange counties	.75
Map No. 26—Huntington Beach Oil Field	.75
Map No. 27—Santa Fe Springs Oil Field	.75
Map No. 28—Torrance, Los Angeles County	.75
Map No. 29—Dominguez, Los Angeles County	.75
Map No. 30—Rosecrans, Los Angeles County	.75
Map No. 31—Inglewood, Los Angeles County	.75
Map No. 32—Seal Beach, Los Angeles and Orange counties	.75
Map No. 33—Rincon, Ventura County	.75
Map No. 34—Mt. Poso, Kern County	.75
Map No. 35—Round Mountain, Kern County	.75
Map No. 36—Kettleman Hills, Kings County	1.25
Map No. 37—Montebello, Los Angeles County	.75
Map No. 38—Whittier, Los Angeles County	.75
Map No. 39—West Coyote, Los Angeles and Orange counties	.75
Map No. 40—Elwood, Santa Barbara County	.75
Map No. 41—Potrero, Los Angeles County	.75
Map No. 42—Playa Del Rey, Los Angeles County	.75

DETERMINATION OF MINERAL SAMPLES

Samples (limited to three at one time) of any mineral found in the State may be sent to the Division of Mines for identification, and the same will be classified free of charge. No samples will be determined if received from points outside the State. It must be understood that no assays, or quantitative determinations will be made. Samples should be in lump form if possible, and marked plainly with name of sender on outside of package, etc. No samples will be received unless delivery charges are prepaid. A letter should accompany sample, giving locality where mineral was found and the nature of the information desired.

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STATE OF CALIFORNIA
DEPARTMENT OF NATURAL RESOURCES

DIVISION OF MINES

CORDIALLY INVITES YOU TO VISIT
ITS VARIOUS DEPARTMENTS MAINTAINED
FOR THE PURPOSE OF FURTHERING
THE DEVELOPMENT OF THE

MINERAL RESOURCES OF CALIFORNIA

At the service of the public are the scientific reference library and reading room, the general information bureau, the laboratory for the free determination of mineral samples found in the state, and the largest museum of mineral specimens on the Pacific Coast. The time and attention of the State Mineralogist, as well as that of his technical staff, are also at your disposal.

Office hours: 9 a.m. to 5 p.m. daily.
Saturday, 9 a.m. to 12 m.

WALTER W. BRADLEY,
State Mineralogist.

Third floor, Ferry Building, San Francisco, Cal. Branch Offices: Bankers Building, Los Angeles; State Office Building, Sacramento; Chamber of Commerce, Redding; Bank of Italy Building, Bakersfield; San Marcos Building, Santa Barbara; Taft, Coalinga and Santa Paula.

Mining in California

OCTOBER, 1931

PUBLISHED QUARTERLY

STATE OF CALIFORNIA
DEPARTMENT OF NATURAL RESOURCES
DIVISION OF MINES

FERRY BUILDING
SAN FRANCISCO

DIVISION OF MINES

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STATE OF CALIFORNIA
DEPARTMENT OF NATURAL RESOURCES
DIVISION OF MINES
FERRY BUILDING, SAN FRANCISCO

WALTER W. BRADLEY State Mineralogist

Vol. 27 OCTOBER, 1931 No. 4

CHAPTER OF

REPORT XXVII OF THE STATE MINERALOGIST

COVERING

ACTIVITIES OF THE DIVISION OF MINES

INCLUDING THE

GEOLOGIC BRANCH

CALIFORNIA STATE PRINTING OFFICE
HARRY HAMMOND, STATE PRINTER
SACRAMENTO, 1931

TABLE OF CONTENTS

	Page
DISTRICT REPORTS OF MINING ENGINEERS	487
Redding Field Division	487
Sacramento Field Division	488
Alpine County	488
San Francisco Field Division	491
Los Angeles Field Division	491
GEOLOGIC BRANCH	492
Geology of San Jacinto Quadrangle south of San Gorgonio Pass, California	494
OIL FIELD DEVELOPMENT OPERATIONS	541
SPECIAL ARTICLES	543
Notes on Mining Activity in Inyo and Mono Counties in July, 1931	543
ADMINISTRATION	546
MINERALS AND STATISTICS	547
Statistics	547
Museum	550
Laboratory	550
LIBRARY	551
PRODUCERS AND CONSUMERS	562
EMPLOYMENT SERVICE	562
PUBLICATIONS	I
INDEX TO VOLUME XXVII	563

PREFACE

The Division of Mines (formerly State Mining Bureau) is maintained for the purpose of assisting in all possible ways in the development of California's mineral resources.

As one means of offering tangible service to the mining public, the State Mineralogist for many years has issued an annual or a biennial report reviewing in detail the mines and mineral deposits of the various counties.

As a progressive step in advancing the interests of the mineral industry, and as permitting earlier distribution to the public, publication of the Annual Report of the State Mineralogist in the form of monthly chapters was begun in January, 1922, and continued until March, 1923.

Owing to a lack of funds for printing this was changed to a quarterly publication, beginning in September, 1923.

For the same reason, beginning with the January, 1924, issue, it has been necessary to charge a subscription price of $1 per calendar year, payable in advance; single copies, 25 cents apiece. 'Mining in California' is sent without charge to our 'exchange list,' including schools and public libraries, as are also other publications of the Division of Mines.

Pages are numbered consecutively throughout the year and an index to the complete report is included annually in the closing number.

Such a publication admits of several improvements over the former method of procedure. Each issue contains a report of the current development and mining activities of the State, prepared by the district mining engineers. Special articles dealing with various phases of mining and allied subjects by members of the staff and other contributors are included. Mineral production reports formerly issued only as an annual statistical bulletin are published herein as soon as returns from producers are compiled. The executive activities, and those of the laboratory, museum, library, employment service and other features with which the public has had too little acquaintance also are reported.

Beginning with the 1930 issues, the activities and progress of the Geologic Branch are recorded also in these quarterly chapters.

While current activities of all descriptions are covered in these chapters, the practice of issuing from time to time technical reports on special subjects will be continued, as well. A list of such reports now available is appended hereto, and the names of new bulletins will be added in the future as they are completed.

The chapters are subject to revision, correction and improvement. Constructive suggestions from the mining public will be gladly received, and are invited.

The one aim of the Division of Mines is to increase its usefulness and to stimulate the intelligent development of the wonderful, latent resources of the State of California.

•LEGEND•

— Mining Division Boundaries.
O Mining Division Offices.

DISTRICT REPORTS OF MINING ENGINEERS

In 1919–1920 the Mining Bureau was organized into four main geographical divisions, with the field work delegated to a mining engineer in each district, working out from field offices that were established in Redding, Auburn, San Francisco and Los Angeles, respectively. This move brought the office into closer personal contact with operators, and it has many advantages over former methods of conducting field work. In 1923 the Redding and Auburn field offices were consolidated and moved to Sacramento.

The Redding office was reestablished in 1928, and the boundaries of each district adjusted. The counties now included in each of the four divisions, and the locations of the branch offices, are shown on the accompanying outline map of the State. (Frontispiece.)

Reports of mining activities and development in each division, prepared by the district engineer, will continue to appear under the proper field division heading.

Although the petroleum industry is but little affiliated with other branches of mining, oil and gas are among the most valuable mineral products of California, and a report by the State Oil and Gas Supervisor on the current development and general conditions in the State's oil fields is included under this heading.

New County Reports.

The series of separate reports on the mines and mineral resources of the different counties, that together comprise the State Mineralogist's Reports XVI to XVII, inclusive, in the case of many of the counties have become exhausted. Those still in stock being in need of revision, it was deemed advisable, beginning with the January, 1925, issue of 'Mining in California,' to make the district engineers' reports in the form of a complete general report on the mines and mineral resources in one or more of the counties in each district.

This program has been followed as nearly as possible in succeeding numbers of the quarterly, and the county series completed during 1930. A new series of reports on individual economic minerals, mainly nonmetallics, is now (1931) under way.

REDDING FIELD DIVISION

CHAS. V. AVERILL, Mining Engineer

Reports covering the mines and mineral resources of all of the counties in the Redding field division are now available, and field work at present is confined to investigations for special reports upon various economic minerals.

SACRAMENTO FIELD DIVISION

C. A. LOGAN, Mining Engineer

ALPINE COUNTY

The following mining companies were active late in July, 1931, in Alpine County. None are producing.

Alhambra Mining Corporation. Hope Valley Mining District. Colonel J. W. Hopkins, manager. Mine address, Gardnerville, Nevada. A Nevada corporation with an office at 210 Byington Building, Reno. R. Nenzel, secretary.

This company has 15 unpatented quartz locations 13 miles west of Woodfords, on and near Red Lake Peak, elevation 7500–9500 feet. The upper slope of this mountain is covered by ancient schists, derived originally from sedimentary rock, which has been invaded by basic igneous dikes and metamorphosed by contact with the underlying granite and by pressure and folding. On the surface the rock of Red Lake Peak is stained by iron oxide. At the depth reached in the shallow workings, it proves to be a hard quartzitic mica-schist in places nearly all quartz, carrying stringers and seams of pyrite, pyrrhotite, galena, zincblende, chalcopyrite and possibly other sulphides. Many assays of samples indicate gold in quantities varying from $1.80 to $88 a ton, the gold being probably all in the sulphides. Varying amounts of silver are also indicated.

MINERAL PRODUCTION OF ALPINE COUNTY, 1880-1930

Year	Gold	Silver	Copper		Miscellaneous and unapportioned	
			Pounds	Value	Value	Substance
1880	$17,133	$24,146				
1881	2,000	2,100				
1882	20,000	10,000	70,895	$13,115		
1883	10,000	5,000	[1]			
1884	5,000	4,000				
1885						
1896	400					
1897						
1901	23,568	2,860	8,377	1,319		
1902	10,359	3,770				
1903	2,701	146				
1904	4,827	145				
1905	575					
1909					$5,465	Unapportioned, 1900-1909
1913	537	4				
1914						
1919					100	Crushed rock.
1920	[2]	[2]			680 160	Miscellaneous stone. Gold and silver.
1921					925	Miscellaneous stone.
1922					2,800	Miscellaneous stone.
1923						No commercial production.
1924		[2]	[2]		2,552	Lead and stone, miscellaneous.
1925	[2]	[2]			520	Miscellaneous stone.
1926					450	Miscellaneous stone.
1927	146	60			5,100	Miscellaneous stone.
1928	23	363			174 2,800 5,169	Lead. Miscellaneous stone. Copper and granite.
1929			7,260	1,278	31,735	Miscellaneous stone.
1930					2,500	Miscellaneous stone.
Totals	$97,269	$52,594	86,532	$15,712	$61,130	

[1] "Small production of cement copper" reported in 1883, but record does not show exact figures.
[2] Under 'Unapportioned.'

An adit which is a crosscut for about 115 feet connects with a shaft 35 feet deep, then follows a seam of quartz carrying sulphides for 30 feet. It is being advanced in the belief that it may lead to a larger body of good ore when a north-striking plane is encountered, this being the general strike of schistosity of the metamorphic rock. No mill tests have been made yet to determine the general tenor of ore, but it would be interesting to run small lots from the numerous claims on the four large outcrops found.

Natural conditions favor cheap mining on a good-sized scale if development proves up a sufficient tonnage. The slope of the mountain will permit mining through adits. Crater Lake, elevation 8325 feet and 135 feet above the present workings, furnishes water used to run a compressor and one drill and usually has sufficient water for milling and electric power. Timber is plentiful, but has not been required so far. Three men were employed in July, but work was stopped in August, because of shortage of water. There is a good road to the mine from Minden, Nevada, the nearest railroad point, 30 miles distant. There are two small buildings at the camp, a mile from the site of prospecting.

Alpine Consolidated Mining Company, formed by Hunter, Platt and Fletcher, New York brokers, has taken over all the former holdings of the *Curtz Consolidated Mining Company* (see Report XVII, pp. 401, 403). The adits on the Alpine Mine (a former gold producer) and on the Morning Star (once a producer of enargite and complex silver sulphide ores) are being cleaned out in preparation for further prospecting. Eight men were employed in July, 1931, with C. L. Wilson as superintendent.

Boulder Hill Group was originally located in 1920 at the Buckeye and Deer Horn series of claims and called the *Wolf Creek Group.* The name Boulder Hill had formerly been applied to one of the earlier discoveries nearer Markleeville. The present Boulder Hill group is under option to A. H. Gracey, Markleeville, and associates, who have options also on two other adjoining claims, there being nine quartz claims, two millsites and a campsite in the group. They are near the mouth of Wolf Creek in Sec. 21, T. 9 N., R. 21 E., and reached by five miles of road, leaving the Big Trees Highway eight miles south of Markleeville. Work had been suspended in July, and the writer did not examine the claims.

The vein, which is reported to be a brecciated zone in andesite filled and cemented by silica and carrying gold in pyrite, has been prospected on two adjacent slopes separated by a gulch which crosses the vein. Elevation varies from 6100 feet at the river to 7500 feet. The vein strikes northwest and dips 65° northeast.

Surface assays indicate possibility of an east ore shoot 600 feet long according to Gracey who claims average assays of good grade for a width of two to four feet and length of 300 feet in the upper east adit which gives shallow backs. A proposed lower east adit would give 450 feet vertical depth or 500 feet on the dip of the vein below the upper adit, and would have to be run 800 feet to be under the face of it. Another engineer, who states he sampled the upper east adit, says 160 feet long gave an average assay of $14.60 a ton. A crosscut 2000 feet long from the millsite would give 1000 feet of backs.

On the west, while overburden is said to obscure the vein, it outcrops near the top of the hill where 15 feet in width assays $3.80 a ton and on the hangingwall side a streak 18 inches wide assays $60 a ton, according to Gracey's assays. The lower adit on this side has disclosed the vein and still has it in the face. So far two short ore shoots 40 to 50 feet long have been opened here, with a width of 2½ to 3 feet.

Tunnel work (size 5 ft. by 7 ft.) has been done under contract and has cost about $15 a foot. A total of 690 feet of underground work has been done in the three years of activity. The equipment includes engine, blower, air-pipe and hand tools. Minden, Nevada, the nearest railroad point is 36 miles distant.

Colossus Mining Company, 315 Montgomery Street, San Francisco (John L. Henry) has a lease and option on the old Advance Mine and 19 other claims at Loope. Nothing was being done when the district was visited in July, 1931.

Colorado No. 2 Mine now belongs to Sarita N. Henry and is stated to be at present consolidated with the Colossus group. No work was being done at time of visit.

Drumlummon Claim. Sam Castleman, Placerville, owner. On the northeast slope of Stevens Peak, five miles from the junction of Luther Pass and Carson Pass roads, the last two miles being by trail. It is in the southwest corner of Sec. 2, T. 10 N., R. 18 E.

The claim is only slightly prospected. Specimens of ore brought in show pyrite and chalcopyrite principally. One sample assayed in the Division laboratory carried $9 a ton gold. Stevens Peak is described by Lieutenant George M. Wheeler in Appendix NN to U. S. Geographical Surveys West of the 100th meridian, Ann. R. Chief of Engrs. for 1878, p. 169 as "a mass of red trachyte, containing hornblende, orthoclase and plagioclase. A vast amount of detritus covers the summit. * * * The east side is a perpendicular face of rock for about 400 feet, but on the west the peak curves around toward the north and red trachyte extends to about one-third mile west, then blue diorite with black crystals of hornblende appears. About three fourths mile on ridge northwest of peak the diorite assumes a slaty structure. * * * The lower half of this peak on the east side is gray granite, containing black mica, limpid quartz and white orthoclase."

Good Hope Mine, two miles southeast of Markleeville, was located in 1863, and passed to creditors in 1867. Work done upon it was described by Raymond in his report for 1874.[1] The water became so plentiful in a shaft sunk 32 feet in the footwall that sinking was stopped. An adit was then run. For 200 feet it was in soft porphyry then cut a "clay wall six feet thick which drained off the water from the above shaft, showing this clay to be the true east wall of the ledge." The above report describes the further work, and says that on west wall a solid vein of quartz three feet thick was struck which was followed unbroken for 400 feet southward into the mountain. The vein was reported 10 feet wide in places, and averaged five feet. It varies from soft to hard ore, dip 40° west, strike nearly north and was said to average by mill tests $12.75 a ton. At time of suspension,

[1] Raymond, R. W. Mineral Resources of U. S. West of the Rocky Mountains.

this grade of ore could not be worked at a profit. It lay idle since then until 1931.

Nine claims including this prospect have been located recently and are under option to A. H. Gracey, Markleeville. The crosscut adit had been cleaned out for 200 feet late in July, 1931.

COPPER

Leviathan Mine. This old copper mine, from which high grade ore was mined in the sixties, but which has been unproductive and idle since, is under option to *Western Clay and Metals Company,* Chamber of Commerce Building, Los Angeles. Mr. Walker was in charge, with four or five men employed, reopening old workings in July. Leviathan claims No. 6 to No. 16 were located July 15, 1931.

MOLYBDENUM

Libby Group. Libby Mine, Libby No. 2 and Libby No. 3 were located July 7, August 7 and August 11, 1930, by Charles Christman, 1554 McAllister Street, San Francisco, and W. A. Swank. Libby Mine or No. 1, is about one-fourth mile south of Highland Lake road and north of Mokelumne River. This road turns south from the Big Trees-Alpine Highway just west of the Ebbetts Pass summit. Libby No. 2 is west of No. 1 and one-fourth mile south of Ebbetts Pass road. Libby No. 3 is west of No. 2 and one-fourth mile south of Ebbetts Pass road and north of main Mokelumne River. The claims are near camp of Charles Tryon of Angels Camp. Nothing except assessment work has been done as far as known, and the claims were not visited.

SAN FRANCISCO FIELD DIVISION

C. McK. Laizure, Mining Engineer

Reports covering the mines and mineral resources of all of the counties in the San Francisco field division are now available, and field work at present is confined to investigations for special reports upon various economic minerals.

LOS ANGELES FIELD DIVISION

W. B. Tucker and R. J. Sampson, Mining Engineers

Reports covering the mines and mineral resources of all of the counties in the Los Angeles field division are now available, and field work at present is confined to investigations for special reports upon various economic minerals.

GEOLOGIC BRANCH

OLAF P. JENKINS, Chief Geologist

Progress Report.

Several geological field investigations were carried on during the summer of 1931 under the auspices of the Division of Mines.

(1) The geologic mapping of the Weaverville quadrangle was completed by N. E. A. Hinds, who is now engaged in the preparation of his report.

(2) In San Bernardino County, John C. Hazzard has been mapping and working out the complex geologic structure of the Bristol, Granite, Providence, Ship, and Marble mountains. He is now making a laboratory study of specimens collected and is preparing his report.

(3) Also in San Bernardino County, Dion Gardner continued his geologic study in the Newberry, Ord, and Bristol mountains and is preparing his report.

(4) The geologic mapping of the Sebastopol and Duncan's Mills quadrangles in Sonoma County has been nearly completed by F. A. Johnson.

(5) In northeastern Madera County, Homer D. Erwin has been studying the geology and ore-deposits of a very interesting mineral-bearing region and is now preparing his report.

(6) Considerable progress has been made in the geologic mapping of the Searles Lake quadrangle, San Bernardino, Kern and Inyo counties, by Carlton D. Hulin.

(7) The underground geologic study of a portion of the Grass Valley region, Nevada County, undertaken by the United States Geological Survey in cooperation with the State Division of Mines, has been completed by W. D. Johnston and his assistant R. L. Loofbourow.

(8) Evans B. Mayo is completing his final report on southwestern Mono County.

(9) Edward C. Simpson has about completed his report and geologic map of the Elizabeth Lake quadrangle, Los Angeles and Kern counties.

(10) E. Wayne Galliher is making a careful study in Monterey County of the Carmel Stone as regards its suitability for constructive and decorative purposes.

(11) George Green is continuing his study of the geology of the Hetch Hetchy coast tunnels, in Alameda County.

Beside these eleven investigations in which the Division of Mines is actively cooperating, seven other reports are being prepared, which eventually, it is hoped, will be published in MINING IN CALIFORNIA.

(1) R. Dana Russell is completing a geologic report and map of the Tertiary beds of central northern California.

(2) An interesting physiographic report on the Clear Lake region, Lake County, is in preparation by William Morris Davis.

(3) A general report on the physiography of California is in preparation by N. E. A. Hinds.

(4) Harry MacGinitie has been studying the geology of Humboldt and adjoining counties and is preparing a preliminary report on that little-known region.

(5) Parry Reiche has been studying and mapping the geology of the Lucia quadrangle, Monterey County.

(6) Roger F. Rhoades has been making a geologic study of an almost inaccessible region in northern California, lying northeast of Redding, Shasta County.

(7) Samuel G. Clark has been studying and mapping the complex geology of the region about Covelo, Mendocino County.

The Chief Geologist is steadily progressing with the State Geologic Map, the preliminary drafting of which is being done in cooperation with the United States Geological Survey.

As chairman to a committee, the Chief Geologist is assisting in the preparation of a guidebook of geology in California for the next International Geological Congress, which is to make an extensive excursion throughout the United States in 1933. Several prominent geologists are contributing manuscripts to be used in this guidebook for California. The assembled unpublished material of the State Geologic Map is now being used in the preparation of a complete general geologic map of the entire United States.

A report giving the results of a careful geological study of the San Jacinto quadrangle south of San Gorgonio Pass, Riverside County, by Donald McCoy Fraser, appears in this issue of MINING IN CALIFORNIA. Although the Geologic Branch of the State Division of Mines assisted in supplying expenses for the last summer's field investigation, most of the work is a contribution. We are indebted to the author for submitting his entire report, and to members of the Department of Geology, Columbia University, for their part in supervising the cooperative project.

In the next issue of MINING IN CALIFORNIA will be published a report on the economic mineral deposits of the San Jacinto quadrangle, south of San Gorgonio Pass. The purely scientific article of Fraser's will thus be coordinated with the commercial aspect of geology.

GEOLOGY OF SAN JACINTO QUADRANGLE SOUTH OF SAN GORGONIO PASS, CALIFORNIA*

By Donald McCoy Fraser †

OUTLINE OF REPORT

	Page
INTRODUCTION	495
General Statement	495
Location	496
Conditions of Study	497
Acknowledgments	497
Earlier Investigations	498
GENERAL FEATURES	499
Population and Industries	499
Surface Relief	499
Drainage	501
Climate	501
Vegetation	501
Attempts to Exploit Mineral Deposits	502
GEOMORPHOLOGY	502
GEOLOGIC FORMATIONS	504
General Statement	504
List of Geologic Formations as Described on Map	504
Metamorphic Series	504
Gabbro	508
Granite-Gneiss	509
Granite	510
Mt. Eden Formation	511
Red Bed Member	511
Mt. Eden Beds	512
Bautista Beds	514
STRUCTURAL FEATURES	516
General Statement	516
San Jacinto Fault Zone	516
San Gorgonio Pass Fault Zone	519
Palm Canyon Faults	521
Structures of the Metamorphic Rocks	521
Structures of the Batholithic Rocks	523
Structures of the Later Sediments	524
PETROLOGY	525
Granite	525
Granite-Gneiss	529
Metamorphic Rocks	534
GEOLOGIC HISTORY	536
Summary of Events	536

* Published by permission of the Department of Geology, Columbia University.

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INTRODUCTION

General Statement.

The San Jacinto quadrangle is located 100 miles east of Los Angeles along the dividing range between the Colorado Desert and the valleys of the coastal region.

San Jacinto Peak, elevation 10,805 feet, lies near the center of the area. It is the apex of the three-sided San Jacinto Mountain pyramid, the northern side of which slopes toward San Gorgonio Pass, six miles distant and 9000 feet lower in elevation. This side of the pyramid is

Photo by Cogley Studio, Hemet, Cal.

FIG. 1. View from the southwest toward snow-clad granite peaks of the San Jacinto Mountains, flanked in the bordering low hills by Pleistocene sediments.

very steep; Snow Creek, for example, drops 4000 feet in one mile of its course.

As one of the main gateways to southern California, San Gorgonio Pass, separates the San Jacinto from the San Bernardino mountains. Broad crush-zones and truncated formations in the San Bernardino foothills mark the courses of the great San Andreas rift and associated faults that extend across the northern part of the area.

The eastern side of the mountain block terminates in Palm Canyon and Palm Springs Valley, close to the edge of the quadrangle. In this

latter valley Palm Springs, a famous resort, is situated. With an elevation of only 500 feet, it is thus 10,305 feet lower than San Jacinto Peak, which towers above the valley seven miles to the west.

On the third or southwestern side of the mountain block, the slope is less precipitous. On this side the base of the pyramidal block is outlined by the broad San Jacinto zone of faulting, usually considered to be a southern branch of the San Andreas fault, the dividing point being Cajon Pass, 30 miles northwest of the San Jacinto quadrangle. Within recent years, however, the San Jacinto fault has been much more active than the San Andreas fault. The violent earthquakes of 1899 and 1918 which resulted in destruction in the towns of San Jacinto and Hemet are thought to have originated along the San Jacinto fault. Numerous minor movements have also occurred at various times and shocks are apt to occur at any time. During late Tertiary and Quaternary time, vertical movement amounting to thousands of feet displacement took place along the San Andreas and San Jacinto fault zones. The faults of the area should be of special interest at present on account of their relation to proposed routes of the Hoover Dam-Los Angeles aqueduct which must of necessity cross them. Investigation of the main faults and their associated crush-zones should be a part of preliminary study for any major engineering project in this region.

The region, occupying the southwestern corner of the quadrangle, southwest of the San Jacinto fault zone, is an upland country with a general elevation of three to four thousand feet. The rocks are largely granitic, with schists forming the higher peaks.

The main San Jacinto mountain mass forms a part of a granitic batholith, bounded by marginal metamorphics and sedimentaries, which have been elevated between the two great fault zones mentioned above. The older rocks intruded by the batholith dip away from it at angles of from 30° to 60°. The truncated beds are exposed on the eastern side through a distance of at least four miles, exposing great thicknesses of old sedimentary and intrusive rocks. This is one of the unusually thick sections of Paleozoic and older rocks in southern California.

Pliocene and Pleistocene sediments have been found along the western base of the mountains. These beds, identified on the basis of fossil vertebrate remains, are of value placing the geologic age of movements of the mountain block.

Location.

The area under discussion lies in Riverside County, 25 miles southeast of Riverside. The principal towns of the quadrangle are Hemet and San Jacinto in the west, and Beaumont and Banning in the north. Coachella Valley, at the northwestern end of the Imperial Valley, extends into the northeastern corner of this quadrangle.

The San Jacinto quadrangle is bounded by 30° 30′ and 34° north latitude and 116° 30′ and 117° west longitude. It adjoins the San Gorgonio quadrangle which lies to the north, the Indio Special quadrangle to the east, the Ramona quadrangle to the south and the Elsinore quadrangle to the west.

Conditions of Study.

The field work, covering a total period of five months, was done during the summers of 1927, 1928, and 1930. The laboratory study and preparation of the report was carried on under the direction of the Department of Geology, Columbia University. The area mapped represents the major part of the San Jacinto quadrangle and includes about 800 square miles. The scale of the map used in the field was 1:125,000, contour interval 100 feet, and the field work is considered by the writer to be of somewhat reconnaissance nature.

Acknowledgments.

An examination of the region from the air, of value in tracing the major structural lines of the area, was made possible through the

FIG. 2. Index map of southern California, showing location of San Jacinto quadrangle. The shaded portion is the area covered in this report.

kind cooperation of Major Harmon and Lieutenant Burt of the United States Army Air Corps, March Field, California.

Thanks is due Professor Charles P. Berkey, under whose direction this paper was written, and others of the staff of the Geology Department of Columbia University for advice and criticism pertaining to the various problems of this paper. In particular, appreciation is expressed to Professor Paul F. Kerr for supervision of field work, to Professor Roy J. Colony, and to Professor Douglas W. Johnson for special assistance. Professor John P. Buwalda, of California Institute of Technology, allowed the writer to use the library and laboratories of the Department of Geology and thus facilitated the preparation of several dozens of thin-sections. The Southern Pacific Railroad Company assisted by furnishing copies of a reconnaissance map of part of the area, which helped in mapping faults east of Palm Canyon.

The writer greatly appreciates the financial assistance provided him in field expenses for the summer of 1930 by the Geologic Branch of the California State Division of Mines and for the opportunity to publish the results of his work in MINING IN CALIFORNIA.

Earlier Investigations.

In 1853 W. P. Blake,[1] geologist of the Pacific Railway Survey, briefly described a trip through San Gorgonio Pass. In 1900, E. W. Claypole[2] described the San Jacinto earthquake of 1899. Following the San Francisco earthquake of 1906, A. C. Lawson[3] and others traced the major fault lines through the San Jacinto region. A discussion of the Coahuila Basin was given by E. E. Free[4] in 1914, and in 1915 C. H. Beal[5] studied Imperial Valley faults. During 1916 and 1917 Childs Frick[6] collected vertebrate remains from the western part of the quadrangle and published an account of his work in 1921. An earthquake in the area in 1918 again brought investigation of the fault zones. At this time Ralph Arnold,[7] Frank Rolfe and A. M. Strong,[8] and Sidney D. Townley[9] made studies in the region. In the same year Francis E. Vaughan[10] published a paper on a Pliocene sea in San Gorgonio Pass. Gerald A. Waring's[11] report in 1919 on the water supply of part of the area included a map showing the areal distribution of sedimentary and crystalline rocks, while R. T. Hill's[12] report of 1920 traces certain faults through the area. In Francis E. Vaughan's[13] paper on the San Bernardino Mountains the geology of the district north of San Gorgonio Pass is discussed and is included on his map. In the same year (1922) John S. Brown[14] mentions the San Jacinto area in his work on the Salton Basin. In 1926 and 1928 L. F. Noble[15] and R. T. Hill,[16] respectively, published results of studies of fault lines which are closely associated with the structural history of the San Jacinto area.

[1] Account given in "The Salton Sea" by D. T. MacDougal and collaborators. Carnegie Inst. Wash. Pub. 193, p. 21, 1914.

[2] Claypole, E. W., The earthquake of San Jacinto, December 25, 1899. Am. Geol., vol. 25, Feb. 1900.

[3] Lawson, A. C., Report of Earthquake Investigation Committee on the California Earthquake of April 18, 1906. Carnegie Inst. Wash. Pub. 87, 1908.

[4] Free, E. E., Sketch of the geology and soils of the Coahuila Basin. From "The Salton Sea" by D. T. MacDougal and collaborators. Carnegie Inst. Wash. Pub. 193, 1914.

[5] Beal, C. H., The earthquake in the Imperial Valley, California, June 22, 1915. Bull. Seis. Soc. Am., vol. 5, p. 130, 1915.

[6] Frick, Childs, Extinct vertebrate faunus of the Badlands of Bautista Creek and San Timoteo Canyon, Southern California. Univ. Calif. Pub., Bull. Dept. Geol. Sci., vol. 12, no. 5, pp. 277–424, Dec. 1921.

[7] Arnold, Ralph, Topography and fault system of the region of the San Jacinto earthquake. Bull. Seis. Soc. Am., vol. 8, p. 68, 1918.

[8] Rolfe, F., and Strong, A. M., The earthquake of April 21, 1918, in the San Jacinto Mountains. Bull. Seis. Soc. Am., vol. 8, p. 63, 1918.

[9] Townley, Sidney D., The San Jacinto earthquake of April 21, 1918. Bull. Seis. Soc. Am., vol. 8, p. 45, 1918.

[10] Vaughan, F. E., Evidence in San Gorgonio Pass, Riverside County, of a late Pliocene extension of the Gulf of California. Geol. Soc. Am. Bull. 29, pp. 164–165, 1918.

[11] Waring, G. A., Ground water in the San Jacinto and Temecula basins, California. U. S. G. S. Water Supply Paper 429, 1919.

[12] Hill, R. T., The rifts of Southern California. Bull. Seis. Soc. Am., vol. 10, no. 3, pp. 146–149, 1920.

[13] Vaughan, F. E., Geology of San Bernardino Mountains north of San Gorgonio Pass. Univ. Calif. Pub., Bull. Dept. Geol. Sci., vol. 13, no. 9, pp. 319–411, Dec. 1922.

[14] Brown, J. S., Fault features of Salton Basin, California. Jour. Geol., vol. 30, p. 217, 1922.

[15] Noble, L. F., The San Andreas rift and some other active faults in the desert region of southeastern California. Carnegie Inst. Wash. Yearbook, no. 25, pp. 415–428, 1926.

[16] Hill, R. T., Southern California geology and Los Angeles earthquakes. Published by Southern Calif. Acad. Sci., Los Angeles, 1928.

GENERAL FEATURES

Population and Industries.

Hemet (population 2235 in 1930) and San Jacinto (population 1346 in 1930) are the two main towns of the San Jacinto Valley district. Beaumont and Banning (populations in 1930 of 1332 and 2752, respectively) are the centers of activity in San Gorgonio Pass to the north. These towns have both railroad and highway connections with Los Angeles and other southern California cities.

The chief industries of the region are farming and fruit raising in the valleys and stock grazing in the mountains.

A number of resorts are found in the mountains. Hot sulphur springs have determined the location of Gilman's Relief Hot Springs and Soboba Hot Springs, resorts north of San Jacinto. Palm Springs,

Photo by Frasher's, Pomona, Cal.

FIG. 3. View of San Jacinto Peak from the north. The alluvial fan is derived from Snow Creek. Note the flat-topped spur above fan.

also the site of warm water springs, is rapidly becoming a famous resort. The population of this town varies from 500 to 600 in summer to 5000 or 6000 in winter. No railroad enters Palm Springs, but a highway connects with the San Gorgonio Pass lines of communication. Other resorts include Idyllwild and Tahquitz Lodge on the south side of the mountains, at elevations of close to a mile.

Surface Relief.

As already stated, the surface relief of the area may be described as extreme. The rapid fall from the higher peaks, over 10,000 feet above sea level, to the valleys below at elevations of from 500 to 1200 feet is characteristic of the northeastern slopes. Torrential streams radiating from the heights have notched deep, narrow canyons in the

mountains. These have precipitous walls and are separated by narrow ridges, making the area very rugged.

The districts of sediments to the west and northwest have moderate relief but are quite rough in detail. The extension of the sediments

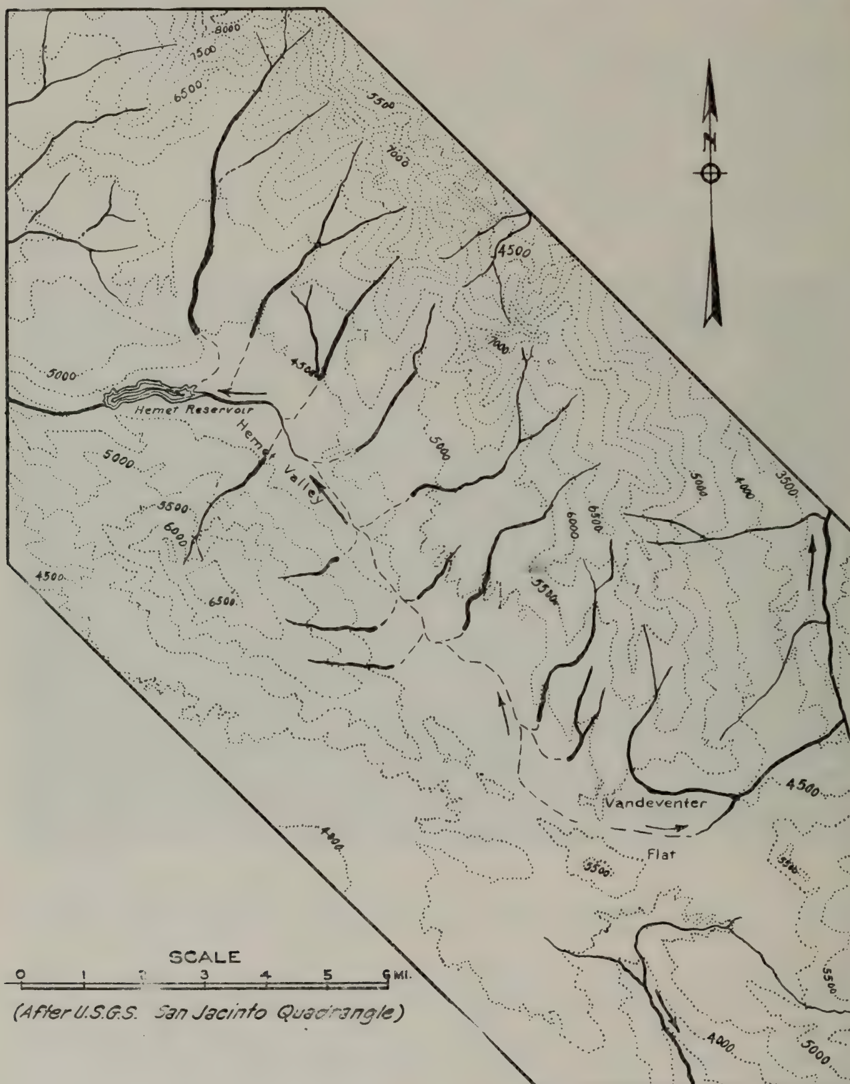


Fig. 4. Map of Hemet Valley and vicinity, showing barbed appearance of the streams which enter the valley. These streams indicate a change in drainage along Hemet Valley.

westward into the Elsinore quadrangle is marked "Badlands," which well describes their nature. This rugged character of the sedimentary areas has resulted from rapid erosion in loosely consolidated material. Slides and local faulting in the weak formations caused by earth movements of the region have only increased the ruggedness.

The region southwest of the San Jacinto fault zone near Sage and Coahuila has strong relief but is markedly different from the area to the northeast, in that it is characterized by extensive upland surfaces.

Drainage.

The larger streams are as follows: San Jacinto River on the southwest slope, with North Fork, Strawberry Creek and South Fork as its main tributaries; Snow Creek flowing from the main peak into San Gorgonio Pass; Tahquitz Creek flowing down the eastern side of the mountain, and having a considerable drainage basin south and east of the higher peaks; and the stream in Palm Canyon draining the southeastern part of the area and flowing north into Coachella Valley. Other streams of fair size are Poppet, Indian, and Potrero creeks, which flow southwest from the San Jacinto Mountains; also West Fork and the streams of Andreas and Murray canyons which flow eastward from the higher peaks.

All of these streams carry large quantities of water during the winter and spring and at times get beyond control and do great damage. For example, in the spring of 1927, in San Gorgonio Pass and San Jacinto Valley long stretches of road and many bridges were destroyed. The flow decreases throughout the summer and by fall some streams are entirely dry. Others continue to flow in their upper course but are dry from their alluvial fans onward. Some water from the western slopes is caught in Hemet Reservoir in the western end of Hemet Valley. This reservoir is the source of some of the water for irrigation of the upper San Jacinto Valley. At times of high water the streams in the northeastern part of the quadrangle flow into Coachella Valley and then southeastward toward Salton Sea. San Jacinto River sometimes floods the lower parts of the San Jacinto Valley, whereupon the water drains to the southwest, past Perris and into Elsinore Lake. Wilson Creek, Coahuila Creek and others in the southwest flow into the Temecula River to the south.

Climate.

Three distinct types of climate are found in the quadrangle. An arid climate prevails in San Gorgonio Pass, Coachella and Palm Springs valleys and the foothills along the northern and eastern base of the mountains. A humid climate characterizes the higher San Jacinto Mountains down to 4500 feet elevation on the southwestern slopes. On the northern and eastern slopes, however, it reaches not lower than 6500 or 7000 feet. In this zone snow falls during the winter and sometimes accumulates to a depth of two or three feet at Hemet Reservoir. The remainder of the area, including San Jacinto Valley and the country to the south, has a semiarid climate.

Vegetation.

The vegetation of the region is roughly divided into two zones. The boundary is in the vicinity of the 4000 and 5000-foot contour lines. Above this irregular boundary is the zone of pines with brush, while below is the zone of brush dominance. The brush is especially thick on the southwestern slopes. Cacti occur throughout the lower zone and are numerous on the alluvial fans and lower ridges of the northern and eastern slopes of the main mountains.

Attempts to Exploit Mineral Deposits.

It was thought at one time that gold in paying quantities existed in the quartz veins at the Hemet Bell Mine at Kenworthy. Several shafts and drifts, dug many years ago, are still open. Kenworthy, however, once a small mining camp, has disappeared and its former location is marked by only one frame house.

FIG. 5. Near view of a network of quartz-feldspar veins which cut the schists of Palm Canyon. Height of section about 10 feet.

Tourmaline in pegmatite is found at several places, among which are the following: The south end of Thomas Mountain, Hays Ranch west of Reed Valley and on the southwestern ridge of Coahuila Mountain at an elevation of 4300 feet. The latter deposit, which is the largest, consists of black tourmaline in a large pegmatite dike. The dike is from 30 to 40 feet thick and has been mined along its strike into the mountain for a distance of over 50 feet. This deposit is still worked occasionally.

Limestone lenses occur in the schists of the Palm Canyon area and with the building of the proposed road from Vandeventer Flat to the Indio district these will be accessible. There are also several limestone lenses in the schists of Dellamont, Claremont and the Potrero Valley district. In the Pinyon Flat region east of the limits of this quadrangle there is an asbestos mine. This deposit, like those of other minerals, has been worked in a small way in the past. Here are found tremolite, asbestos, talc and chlorite, occurring as an alteration zone in an old basic intrusive of the schist series.

GEOMORPHOLOGY

The San Jacinto Mountains may be pictured as a great irregular tetrahedron whose base is an isosceles rather than an equilateral triangle. The sides of the basal triangle have been determined by faults

so that the longest side extends northwest-southeast while one of the two equal sides extends east-west and the other north-south. These sides are respectively about 35 miles, 25 miles and 25 miles in length. The maximum relief is 10,350 feet. In a number of places on the northeast side of the mountains the slope falls 2500 feet in an equal horizontal distance.

Benches have been cut at various levels in this great block of granitic and metamorphic material. These may be due to (1) differential erosion of rocks of varying resistance, (2) erosion during different climatic periods, (3) differential movement of several fault blocks or (4) erosional levels of successive stages of uplift of a unit block mountain. There is one surface with an elevation close to 10,500 feet at the top of the pyramid, another (Tahquitz Valley) whose elevation ranges from 8100 feet to 6500 feet, on its eastern face. Since it is known that large faults nearly surround the pyramid, the most logical explanation of the flat-topped crest-ridge of the peaks and the gentler slope of Tahquitz Valley is successive uplifts of the mountain block, each uplift being preceded by the development of an erosion level.

The most conspicuous bench of the San Jacinto Mountains is found on the southwestern slope. It extends the entire length of the mountain face and lies at an elevation of close to 5200 feet, or about a mile below the high-peaks level. It is believed that the entire bench of the southwestern pyramidal slope has resulted from relative uplift of the San Jacinto Mountains. If the bench has reached its present elevation as a result of uplift of the mountain block relative to the San Jacinto

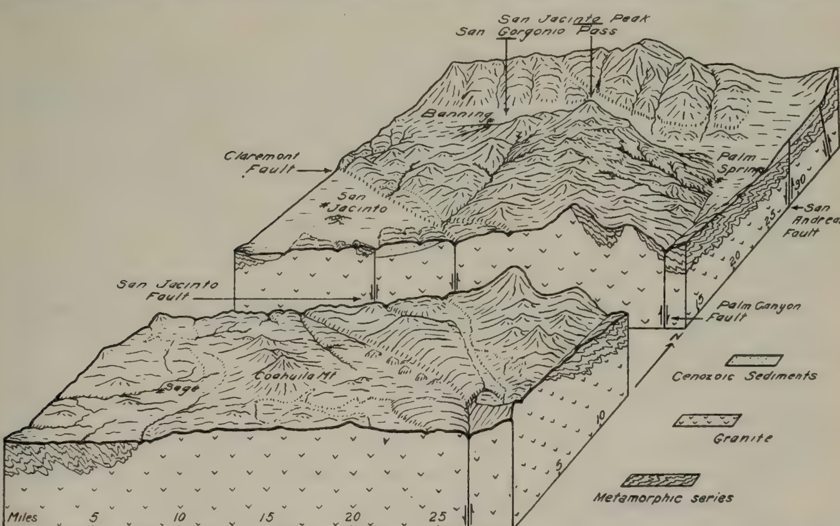


FIG. 6. Block diagram of the San Jacinto quadrangle, showing in general the principal geologic features of the area.

Valley block, it seems reasonable to suppose that it was originally cut by stream planation at an elevation near that of the alluvial plain below.

It has been noted that the higher-peaks surface has an elevation of about 10,500 feet, the Tahquitz Valley slope an elevation of about 7500 feet, and the southwestern slope bench an elevation of about 5200

feet. These indicate that erosion of the pyramid was interrupted by at least three marked periods of more rapid uplift, the first of which elevated the block nearly 3000 feet; the second, approximately 2000 feet. The last period of active uplift, which is continuing at the present time (as evidenced by entrenched streams and recent earthquakes) elevated the mountain mass from 2000 to 3000 feet above San Jacinto Valley.

GEOLOGIC FORMATIONS

General Statement.

The formations in the San Jacinto Mountains include igneous, sedimentary and metamorphic rocks and range in age from Paleozoic or older to Recent. Most of the igneous rocks are granitic and are related to the Sierra Nevada Jura-Cretaceous intrusion. All of the unmetamorphosed sediments are of terrestrial origin of late Tertiary or Quaternary age. The metamorphic rocks are composed of gneisses and schists of probable Paleozoic age.

List of Geologic Formations as Described on the Map

SEDIMENTARY ROCKS

Quaternary

Alluvium (Qal)

(Sand and soil of the valley floors and stream debris.)

Bautista beds (Qb)

(Coarse, loosely consolidated, lenticular, grayish sandstone and poorly lithified shale.)

Tertiary (Pliocene)

Mt. Eden formation (Tme)

(Non-marine shale and sandstone series forming loosely consolidated strata, tan in color, containing vertebrate fossils.)

Red Bed member (Mt. Eden formation) (Tmer)

(Massive, arkosic red-beds grading upward into massive gray sandstone and shale.)

IGNEOUS ROCKS

Jurassic (?)

Granite (gr)

(Typical granite and the most widely distributed rock in the San Jacinto quadrangle.)

Granite-gneiss (gr-gn)

(Gneissoid marginal phase of the granite.)

Age Unknown

Gabbro (gb)

(Dense, black to greenish black rock with a tendency to gneissoid structure. Post-metamorphic and pre-granitic in age.)

METAMORPHIC ROCKS

Paleozoic or older

Metamorphic series (um)

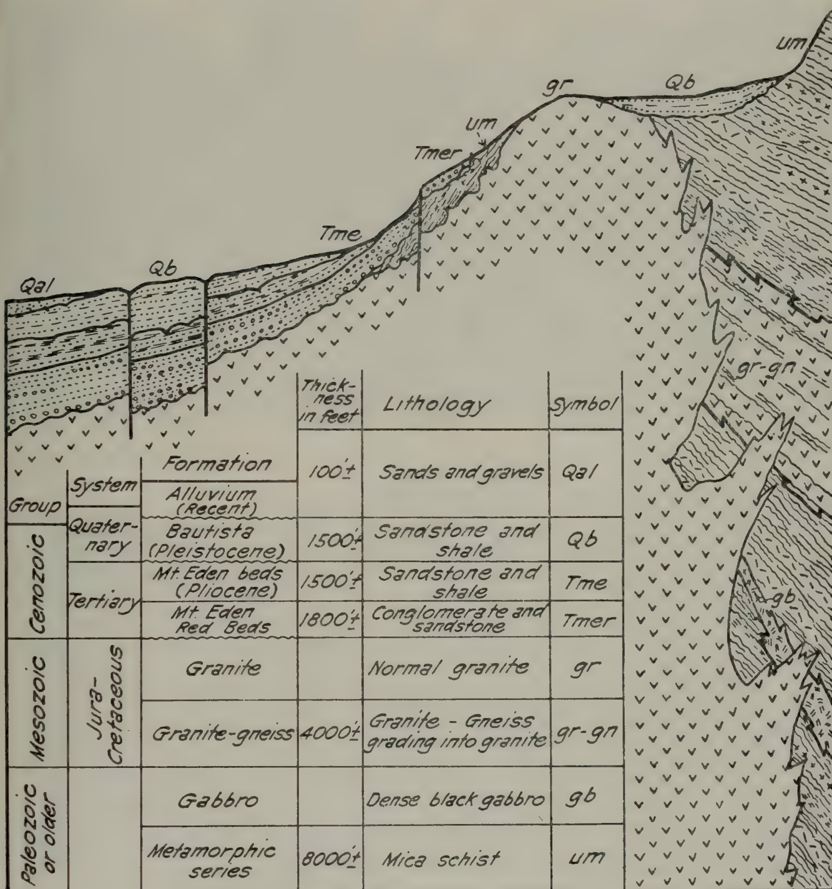
(Predominantly mica schist, also minor amounts of hornblende schist, limestone and quartzite.)

Metamorphic Series.

A great series of undifferentiated schists is well exposed in the eastern wall of Palm Canyon. The largest outcrops of the schist occur

on Coahuila Mountain, Dellamont Peak and the slopes adjoining Palm Canyon. Smaller patches are found on all sides of the San Jacinto Mountains. The schists have been intruded by the batholithic rock and as a rule dip away from the higher peaks of the region. In the Palm Canyon district this old series of rocks dips eastward. The angle of dip is usually about 35° but in places near the crest of the range west of Palm Canyon it increases to 50° or 60°.

The layers are highly lenticular; some of them lens out along their strike in a distance of a mile or two while others extend only a few



Group	System	Formation	Thickness in feet	Lithology	Symbol
Cenozoic	Quaternary	Alluvium (Recent)	100'±	Sands and gravels	Qal
		Bautista (Pleistocene)	1500'±	Sandstone and shale	Qb
	Tertiary	Mt. Eden beds (Pliocene)	1500'±	Sandstone and shale	Tme
		Mt. Eden Red Beds	1800'±	Conglomerate and sandstone	Tmer
Mesozoic	Jura-Cretaceous	Granite		Normal granite	gr
		Granite-gneiss	4000'±	Granite - Gneiss grading into granite	gr-gn
Paleozoic or older		Gabbro		Dense black gabbro	gb
		Metamorphic series	8000'±	Mica schist	um

FIG. 7. Diagrammatic sketch showing sequence of geological formations of the San Jacinto Mountains.

hundred feet before disappearing by gradual thinning. Contorted layers are not common and where found usually lie close to the granitic contact and are noticeably injected.

Crystalline limestone, quartzite, biotite-feldspathic schist, hornblende schist, mica schist, injected schists and well-banded granitic gneisses make up the series. Limestone lenses occur in larger outcrops of the schists and are especially numerous in the southern Palm Canyon area east and northeast of Vandeventer Flat.

A typical section of the schists and later intrusive members associated with the San Jacinto batholith is given below. This sequence was found between the eastern edge of Palm Springs Valley opposite the mouth of Andreas Canyon and a point about a mile to the east.

FIG. 8. View of limestone outcrop east of Palm Canyon. Peaks in the distance are 7 miles away.

	Approximate thickness in feet
Granite-gneiss	600
Muscovite-biotite-feldspathic schist	150
Crystalline limestone with silicate nodules	20
Muscovite-biotite-feldspathic schist	500
Granite-gneiss	400
Biotite-feldspathic schist	300
Gneissic schist	150
Biotite-feldspathic schist	100
Granite-gneiss	250
Coarse biotite-schist	150
	2620

Much of the schist of the Coahuila Mountain district is composed of numerous thin members. In some places, however, through a thickness of several hundred feet of the schist series, a biotite-feldspathic gneiss is the dominant rock. This rock, composed of quartz-feldspar bands one inch or less in thickness interlayered with bands of biotite and muscovite, also occurs in other schist areas of the southwestern part of the quadrangle.

In the Palm Canyon region the edges of the tilted strata are exposed for a distance of four miles along the course of West Fork. The surface here slopes eastward in the direction of dip at $12\frac{1}{2}°$, with a difference in elevation between the highest and lowest outcrop of about 4500 feet. The dip of the schists in this area is at least 35°. Using these figures, the thickness of the metamorphic series is estimated

to be about 8000 feet. This figure has been determined for the schists west of the Palm Canyon fault and does not include the section lying east of the fault. It is to be noted that this figure represents the present thickness of the schists in a specific district but it may indicate little regarding the depth of the original sediments, which may now be greatly increased as a result of isoclinal folding.

The age of the metamorphic series is unknown. Limestones occur north of Vandeventer Flat but are so intensely altered that fossil remains, if ever present, would have been greatly changed. Graphite flakes in places in the limestone indicate the probable former existence of plant or animal remains.

The metamorphics must be older than the granite batholith which intrudes them. They must have been altered before the entrance of the magma into them directly, because now the degree of metamorphism of the schists near the contact is not noticeably more intense than it is some miles away. It therefore seems unlikely that the metamorphism was directly due to intrusion. This presupposes a period of metamorphism preceding batholithic intrusion and involves deep burial of the original sediments following their deposition. Such a series of events without doubt indicates a great lapse of time from the original accumulation of the sediments to the present erosion of their metamorphic derivatives. A statement of "great age" means little, however, when one wishes to fix the age of the rocks as pre-Cambrian, early Paleozoic, late Paleozoic or early Mesozoic.

Photo by Frasher's, Pomona, Cal.

FIG. 9. View of Murray Hill and surrounding area southeast of Palm Springs Valley composed of various schists.

Mesozoic rocks are scarce and one area of Triassic slates and quartzites in the Santa Ana Mountains described by Mendenhall[17] and

[17] Mendenhall, W. C., In Bailey Willis' Index of the Stratigraphy of North America. U. S. Geol. Surv. Prof. Paper 71, p. 505, 1912.

later by Dickerson[18] does not appear to be closely related to the schists of the San Jacinto Mountains, because of structural and lithologic differences. It is likely, then, that these schists are Paleozoic or pre-Cambrian in age. Vaughan[19] found quartzites and limestones of early Paleozoic age in the San Bernardino Mountains to the north. The column there consisted of Arrastre quartzite (probably Lower Cambrian), Furnace limestone (probably Upper Cambrian and Lower Ordovician)[20] and Saragossa quartzite (probably Silurian or Devonian). These are associated with undifferentiated schists, the age relations of which are uncertain.

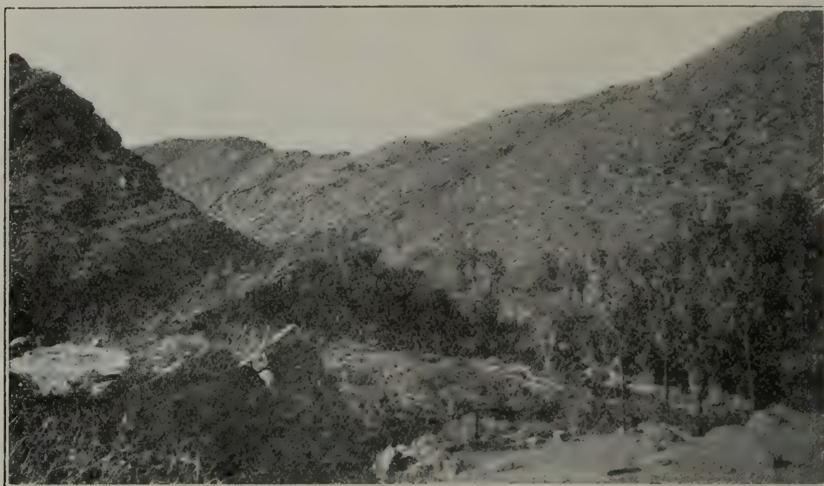


FIG. 10. Looking up Palm Canyon toward the south, showing exposures of granite-gneiss.

Considering these sediments to the north and the sequence in Palm Canyon of metamorphosed sandstones and shales in which numerous limestone lenses occur (some of which are over one-quarter of a mile in thickness) the age is probably Paleozoic or older. To be sure, this is an unsatisfactory statement and the situation is not eased by the knowledge that Vaughan's determinations of the beds to the north were based on lithologic and stratigraphic similarities, that is, on physical rather than organic criteria.

Gabbro.

The gabbro on Oak Mountain is dense, granitoid to rudely gneissose in texture, black to greenish-black in color, weathering to brown or grayish-brown. Small outcrops of gabbro, similar to that comprising Oak Mountain in the southwest corner of the quadrangle, are also found on Coahuila and Thomas mountains and are classed with the

[18] Dickerson, R. E., Martinez and Tejon Eocene and associated formations of the Santa Ana Mountains. Univ. Calif. Publ., Dept. Geol. Sci., vol. 8, p. 261, 1914.

[19] Vaughan, F. E., Geology of the San Bernardino mountains north of San Gorgonio Pass. Univ. Calif., Publ., Dept. Geol. Sci., vol. 12, no. 9, pp. 319–411. Dec. 1922.

[20] Editor's note: "a Mississippian (?) age is suggested for at least a part of the Furnace formation"—A. O. Woodford and T. F. Harris, Geology of Blackhawk Canyon, San Bernardino Mountains, California. Univ. Cal. Publ., Geol. Sci., vol. 17, p. 270, 1928.

former much larger area. The gabbro is considered younger than the metamorphic rocks and older than the granite.

Granite-Gneiss.

The granite-gneiss is found as a marginal phase of the main granite formation and is confined to the eastern part of the area. The largest outcrop extends north-south, forming the western side of Palm Canyon. Excellent exposures of this rock are found in and near Andreas Canyon. It is massively banded, granitoid, gray in color where fresh, and mahogany or dark rust color where weathered.

Smaller areas of this gneiss occur as lenses in the schists east of Palm Canyon and make up the granite-gneiss layers shown in the foregoing table, under the description of the metamorphic series. Here the outcrops are usually quite similar to the larger body, in that they weather to a dark red-brown color and have the same general mineral content. These smaller areas, however, show considerable diversity of texture and because of weathering along old fault planes in places give rise to greenish as well as brownish alteration colors.

That the granite-gneiss is intrusive into the metamorphic series is indicated by the injected character indicated along the contacts and the penetration and contact metamorphism of the limestone beds and also by the occurrence of occasional small patches of schist within the gneiss. One of these xenoliths, in which limestone was present, is

FIG. 11. View of Lily Rock from the north. A granite outcrop on the west side of Tahquitz Mountain.

located at an elevation of about 1000 feet in the large spur northwest of Garden of Eden. The thickness of the granite-gneiss, taken near Andreas Canyon, and computed in the same manner as was the thickness of the metamorphic series, is approximately 4000 feet.

Since the granite-gneiss is a marginal phase of the granite, it is also of probable Jura-Cretaceous age. There is no sharp contact

between the two formations. Robert Balk has suggested that the relations here may be similar to those of the Sierra Nevada intrusives as determined by H. Cloos and R. Balk [21]. That is, the granite-gneiss may be a border phase of the granite. The structural and petrological relations of these two rocks are later discussed in greater detail.

Granite.

The extensive mass of igneous material making up the body of the San Jacinto Mountains is granite. It is best observed near Tahquitz Peak, where a 3300-foot area is exposed. Granitic material is by far the most abundant rock in the quadrangle. Approximately 200 square miles of area occurs in the higher mountains and an equal area is to be found in the Sage Hills Upland region to the southwest. To the north the granite passes beneath the alluvium of San Gorgonio Pass, eastward it has intruded the metamorphic series along Palm Canyon and to the west and southwest it is locally bounded by metamorphics or covered by sediments. The metamorphic-igneous contact line, as shown on the areal map, is often quite irregular, in extreme cases leaving only isolated areas of metamorphic rocks. This is the result of erosion having descended close to the contact, in places reaching, in others going below, this surface.

Considering the age of the granite, it is found that many of the smaller granitic masses lying south and southeast of the Sierra Nevada have characteristics similar to those of the granites of the main range. These smaller bodies have usually been regarded as of the same age. Lawson[22] in his report on an area in the southern Sierras states: "The granites of the region are instrusive in rocks which, as the fossils collected by Becker indicate, are of Triassic age. They may, therefore, with little hesitation, be regarded as having originated at the time of the intrusion of the granites of the more northern portion of the range and these are of post-Jurassic age." In the Cuyamaca Mountains to the south, Hudson [23] discusses a "quartz-diorite batholith developed in post-Triassic time and probably equivalent to the post-Mariposa intrusions of the Sierra Nevada." In the San Gorgonio quadrangle a granite closely resembling the granite of the San Jacinto area is discussed by Vaughan [24] as follows:

"At the close of Jurassic time there was a great invasion of granitic rocks throughout the Sierra Nevada, and these have been traced down into the San Gabriels. It therefore seems fitting to assign the latest granites of the San Bernardino Mountains, herein referred to as the Cactus granite, to the same age. . ."

In a similar manner on the basis of proximity of areal location, of general lithologic similarity and of probable similar Mesozoic history, the granite of the San Jacinto Mountains will be considered of Jurassic-Cretaceous age.

[21] Cloos, Hans, Bau und Bewegung der Begirge in Nordamerika, Skondinavien und Mitteleuropa. Berlin, Gebruder Borntraeger, 1928. Translation of pages 245–264 by R. Balk.

[22] Lawson, Andrew C., The geomorphology of the Upper Kern Basin. Univ. Calif. Publ., Dept. Geol. Sci., vol. 3, no. 15, p. 362, 1904.

[23] Hudson, F. S., Geology of the Cuyamaca region of California with special reference to the origin of the nickelferous pyrrhotite. Univ. Calif. Publ., Bull. Dept. Geol. Sci., vol. 13, no. 6, pp. 175–252, June, 1922.

[24] *Op. cit.*, pp. 319–411.

Mt. Eden Formation.

Red Bed Member.

The red bed member of the Mt. Eden formation in the area of Potrero San Jacinto Nuevo, north of Claremont and Dellamont peaks is well exposed along Potrero Creek and its tributaries.

In the lower part, massive, arkosic red beds predominate, grading upward into massive, gray, arkosic and gritty sandstone. Near the top the strata change to finer grits and sandstones which have a gray or

Fig. 12. Exposure showing conformable contact (indicated by white line) separating the overlying Mt. Eden shale and sandstone from the underlying red-bed member, which is here composed of coarse sandstone and grit.

greenish-gray color and exhibit better sorting and stratification than do the basal beds.

The coarser red and gray beds in this lower member of the Mt. Eden formation were probably deposited by streams flowing from igneous and metamorphic areas into a flatter country which acted as a depositional basin. The climate was probably arid and subject to fluctuations, giving rise to alternate red and gray beds. During this stage there probably was not at all times a water-filled basin of deposition. The upper strata were probably deposited in a shallow lake basin under uniformly less arid climatic conditions than the lower beds.

No fossils were found in these beds; therefore, their definite geologic age is not known. They underlie the fossiliferous Mt. Eden beds to the northwest, however, which represent the upper division of the Lower Pliocene. The lower red beds are distinctly more indurated and more resistant than the overlying Mt. Eden formation, and though there is no evident unconformity it may be possible that the red beds are of Miocene age. The Potato sandstone of the San Bernardino Mountains to the north was tentatively considered by Vaughan [25] to be Miocene, and it may be that this sandstone should be correlated with the red bed member under discussion.

The formation strikes northwest and dips to the northeast at angles ranging from 9° to 18°. The beds are not folded and they exhibit a number of breaks and small faults rather than single planes of great movement. In general, the red beds have greater continuity and are broken and displaced to a smaller extent than are the overlying Mt. Eden beds. As the former are older, this condition indicates that the movements affecting both formations must be chiefly post-Mt. Eden and that the greater disturbance in the overlying Mt. Eden beds is due to their lack of general induration and a greater tendency to slump.

Measuring along a line, approximately normal to the strike, N. 25° E. from the contact with the metamorphics on the southwest to the contact with the Mt. Eden beds on the north and assuming an average dip of 10°, the thickness of the red bed member is estimated to be approximately 1800 feet.

Mt. Eden Beds.

The Mt. Eden formation was originally named the Eden beds by Frick.[26] The age of these beds was determined by him as the upper division of Lower Pliocene. He found vertebrate remains at several localities and after considerable excavating at these places he obtained material from which *Pliohippus, Procamelus, Pliauchenia* and fish remains were identified. Recently, however, he has thought that the formation may be closer to the Upper Pliocene [27] but nothing definite has yet been published as regards this matter. Since the name Eden was previously used for an Ordovician formation and thus has priority over it, at Frick's suggestion [28] the name Mt. Eden is herein substituted and used to designate the Lower Pliocene sandstones and shales which occupy the region about Beaumont. The name is taken from Mt. Eden, a rather large hill of schist lying just west of the San Jacinto

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[25] *Op. cit.*, p. 374.

[26] Frick, Childs, Extinct vertebrate faunas of the Badlands of Bautista Creek and San Timoteo Canon, Southern California. Univ. Calif. Pub., Bull. Dept. Geol. Sci., vol. 12, no. 5, pp. 283–288, Dec. 1921.

[27] Personal communication.

[28] Personal communication.

quadrangle upon the slopes of which the sediments were deposited and are now well exposed. The beds outcrop in an area of 9 or 10 square miles. The sediments have been deposited on a tongue of granitic rock which extends from the east. Two granite inliers occur farther to the west.

One mile south of Beaumont the Mt. Eden beds are found to be covered partly by later valley alluvium. It would be impossible to draw an accurate contact line between these formations, as soil and cultivated fields extend over this contact.

The Mt. Eden formation is made up of sandstones and shales. They are only moderately indurated and therefore slumping of the steep slopes formed by the rapid down-cutting of streams is common. The sandstones are grayish to buff, with occasional green and blue tints. They are coarse to medium to fine-grained, with arkosic layers not uncommon. Massive beds may, by increase of biotite, become micaceous

FIG. 13. Looking toward the north between Lamb Canyon and Potrero Valley, showing dissection of Mt. Eden sediments.

and more definitely stratified. Interbedded shales, having gray, tan and blue tinges, vary in texture from sandy-shales to silt-shales.

Near the eastern edge of the area, between the granitic tongue on the north and Potrero San Jacinto Nuevo on the south, some concretions were found in a massive shale member containing a few plant remains which Chaney [29] determined to be of Miocene or later age.

The strata have the same strike and dip as the underlying red beds, which outcrop to the northwest and northeast. The angle of dip is variable, ranging from 6° to 18°. The formation has suffered minor folding in places, but the chief disturbance to the strata has been movement along fracture planes producing numerous small faults. Although the displacement along many of these planes consists of only a few inches or a few feet, it is often sufficient to produce changes of dip. The thickness of this formation is estimated to be at least 1500 feet. From a study of the present structure and distribution of

[29] Personal communication.

the Mt. Eden sediments much may be learned regarding the conditions of their deposition. The red beds are now found extending to the divide and even over to the southern slopes of Dellamont-Claremont peaks. The depositional contact of sediments with both metamorphic and igneous rocks of Potrero Valley indicates that erosion must have removed the metamorphics in places previous to Mt. Eden red bed deposition. At its western end the Lawrence fault passes under the Mt. Eden beds, which extend up the valley. It would appear that the

FIG. 14. View from the west, showing upper part of Blaisdell alluvial fan.

valley had been formed along the fault prior to the deposition of the sediments. The surface crystalline rocks north of a line marking the westward continuation of the Lawrence fault are granitic, while those to the south in the sedimentary area are chiefly metamorphic. These facts indicate that fault block is on the up-thrown side. The history of this district, in outline, was probably as follows: Deposition of old sediments, minor intrusion, regional metamorphism, intrusion of San Jacinto batholith, faulting and uplift, erosion, red bed deposition, Mt. Eden deposition, faulting and uplift, with northward tilting and erosion.

Bautista Beds.

The sediments lying east and southeast of San Jacinto and Hemet, and north of the lower part of Bautista Creek, have been named by Frick the Bautista beds. They cover an area of about 25 square miles and have a larger surface distribution than that of any other sedimentary formation of the region.

The Bautista sediments consist of interstratified grayish standstones and shales. Only occasionally are conglomeratic layers encountered and these appear to be lens-shaped. The beds in general are grayish to buff in color, friable, and fine-grained. At many places layers of earthy calcareous tufa are present, representing deposits from springs which no longer exist. Frick[30] observed the calcareous pipes in the

[30] *Op. cit.*, p. 291.

Bautista beds and stated "they point to the former prevalence of hot springs." These were the feeders to the calcareous deposits above.

Bench gravels are found on the terraces cut in the Bautista beds south of San Jacinto River. As the underlying beds are almost completely free of cobblestone layers, it is inferred that the streams which deposited the sands and silts of that earlier time were much weaker than San Jacinto River when it cut the terraces.

The San Jacinto River cuts across this sedimentary rock area and separates the Bautista area proper, lying south of the river, from the Soboba dsitrict which occupies an embayment in the mountains to the northeast.

In the Soboba district the strata dip to the south and southwest. The angle of dip varies greatly. The beds are not folded but are badly broken; movements along many small faults, accompanied by slides, have so mangled these beds that small local unconformities with variable dip and strike are common. A good example of a local unconformity is seen in the north bank of the channel at the junction of Indian Creek with San Jacinto River.

The sediments lying between San Jacinto River and Bautista Creek strike northwest-southeast and dip northeast at an average angle of 20°. Owing to the presence of faults, an accurate measurement of the thickness of this formation is impossible, but it is probably 1500 or 2000 feet thick. Vertebrate remains found in these beds by Frick[31] have fixed the age of deposition as Pleistocene.

FIG. 15. View of inverted sand fan along Whitewater spur. The sand is being blown over the ridge toward the observer.

In the Vandeventer Flat area the upper course of Horse Canyon, in the southeastern corner of the quadrangle, cuts an isolated series of sedimentary rocks to a depth of four to five hundred feet. The beds have an areal extent of 8 or 10 square miles and are found at elevations of about 4500 feet. They are composed chiefly of arkosic sandstones with rather numerous pebble layers, especially in their southern

[31] *Op. cit.*, pp. 283–288.

exposure. In a few places fine sandy layers occur. These have a bluish color, while the coarser beds are gray and tan. Although the layers are compacted they are but slightly indurated and are therefore easily eroded.

No fossils were found in these beds, but because of the similarity of lithology and degree of induration between them and the Bautista sediments, they are tentatively considered as Pleistocene. The strata strike nearly east and west. They dip northward at an angle of 5°, except at the southeastern edge of the area where dips as high as 18° were measured. The maximum thickness is estimated to be about 500 feet.

Small areas of arkosic sediments occur in the southeastern part of Diamond Valley and along Bautista Creek at its intersection with Horse Creek, a tributary entering from the northeast. These sediments are lithologically similar to the Bautista beds, and are therefore tentatively considered to be Pleistocene in age.

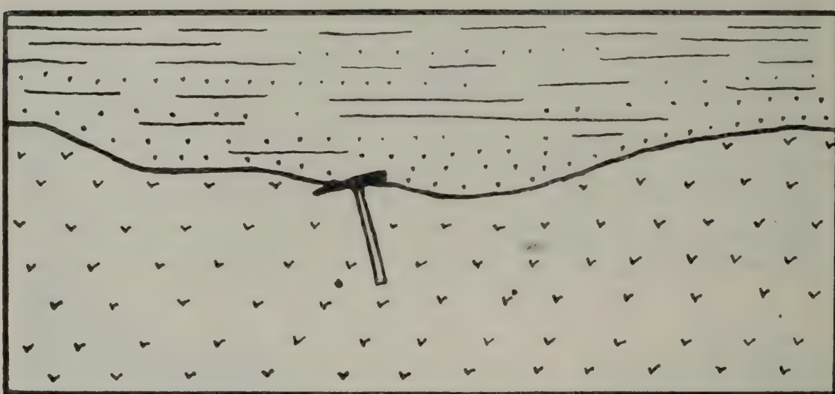

FIG. 16. Sketch from a photograph, showing Pleistocene-Bautista sediments overlying granite.

STRUCTURAL FEATURES

General Statement.

Fault structures dominate the region. They cut across the area in straight and broadly curved lines, regardless of the type of rock or the relief. The more important zones of faulting in the San Jacinto quadrangle may be grouped as follows: (1) San Jacinto zone, (2) San Gorgonio Pass zone, and (3) Palm Canyon zone.

San Jacinto Fault Zone.

The San Jacinto fault zone lies along the southwestern edge of the higher mountains. It varies from two to six miles in width. It includes an elongated region in which the rocks have been badly fractured and in which there are several planes of active movement characterized by intense granulation and mashing. Offset strata, fault and fault-line scarps, undrained areas, and rift zones indicate the position of the faults.

The resistant granitic rock of the San Jacinto batholith is as badly mashed and brecciated along the faults as are the later sediments. In

places the degree of mashing is even greater in granitic rocks than that in the sediments, which indicates that movement occurred in the granite both before and after the deposition of sediments.

San Jacinto fault is a major branch of the well-known San Andreas fault. At various times the town of San Jacinto has been visited by earthquakes which have overthrown its buildings and cracked its streets. Fissures produced in the soil near the town as a result of these quakes indicate the proximity of the fault line. This fault line probably passes just north of San Jacinto, extending southeastward between Park Hill and Florida and up Bautista Canyon. Its continuation southeastward is marked by Rouse Creek, the straight courses of Bautista Creek tributaries, and the juxtaposition of granitic and metamorphic rocks. Hog Lake, a sag pond south of Thomas Mountain and crush zones in the small southern spurs of the same mountain mark the continuation of the plane of movement. Southeastward from here the fault is well marked by the rift topography of Burnt Valley and by Horse Canyon.

A specimen of clay gouge was obtained from a well located within a few hundred feet of the edge of the valley along the base of Claremont Mountain, northeast of San Jacinto. Clay gouge was also reported in a second well drilled one-half or three-quarters of a mile southwest of the first. These occurrences indicate a broad belt of crushing in which there must be several planes of intense movement and mashing.

Hill [32] mapped the San Jacinto fault west of Hog Lake, whereas Strong and Rolfe [33] carried it through the lake. Arnold [34] also felt that the latter location was the better "as Hog Lake is one of the most characteristic forms of fault topography in the entire region under discussion. . ." The alignment of Hog Lake with crush zones in the spurs of Thomas Mountain to the southeast and with the stream valley northwest of Hog Lake also indicates that it lies on the fractured fault zone.

Lawson [35] shows the San Jacinto fault crossing the San Jacinto quadrangle in an almost straight line and draws it from San Jacinto southeastward along the crest of the ridge between San Jacinto River and Bautista Creek to a point two miles southwest of the Hemet Reservoir. Here it follows the steep southwestern side of the ridge and passes on to Burnt Valley. In the area northeast of Hog Lake and also for three or four miles to the northwest, fault-line scarps are found. These indicate a zone of fracturing, possibly a parallel fault, which is not as sharply defined nor as active as the fault through Hog Lake and the upper northeastern tributaries of Bautista Creek.

In the upper course of Horse Canyon Creek, located in Pleistocene sediments, the fault is followed by the stream. At a number of points along the upper three miles of this canyon, displaced strata may be observed. This is best shown in the spurs extending from the southern wall of the valley. Relative to the northern block, the southern block

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[32] Hill, Robt. T., The rifts of Southern California. Seis. Soc. Am., Bull., vol. 10, no. 3, pp. 146–149, 1920.

[33] Rolfe, Frank, and Strong, A. M., The earthquake of April 21, 1918, in the San Jacinto Mountains. Seis. Soc. Am., Bull., vol. 8, p. 63, 1918.

[34] Arnold, Ralph, Topography and fault system of the region of the San Jacinto earthquake. Seis. Soc. Am., Bull., vol. 8, p. 68, 1918.

[35] Lawson, A. C., Report of Earthquake Investigation Committee on the California Earthquake of April 18, 1906. Carnegie Institute Washington, Publ. 87, 1908.

has been raised. As a result the edges of the beds to the north have been sharply upturned. The normal angle of dip of the beds a hundred feet from the fault is 5°, but at the fault this increases to 50° or 60°.

In the San Jacinto district the San Jacinto fault has been drawn from the mouth of Bautista Creek northwestward through the town of San Jacinto. This divides the sediments of Park Hill from the remainder of the sedimentary area and accounts for the present isolation of Park Hill, either by unequal uplift or by more rapid erosion along the crushed zone.

Hill [36] compiled statistics of earthquake shocks reported in southern California for the period from 1780 to 1928 and showed that 170 shocks are to be distributed as follows: "San Jacinto Rift, 92; San Andreas Rift, 16; Elsinore Rift * * * 16; Inglewood, 14; Los Angeles City, 2; and some 30 uncorrected shocks from distant localities." It is seen from these figures that during the last 150 years the San Jacinto Rift has been the source of nearly six times as many shocks as has the San Andreas Rift or any other single rift zone of the southern part of the state. The importance of the San Jacinto zone is further appreciated when it is noted that of this large number of shocks at least two, those of 1899 and 1918, were severe. With these data in mind it must be concluded that the San Jacinto zone of faulting has been correctly described by Hill [37] as "* * * the most active fault line in southern California * * *."

The Hot Springs or Claremont fault lies along the northeastern edge of this fault zone. South and west of Claremont Mountain, truncated spurs and faulted drainage indicate its course. Near Soboba Hot Springs, two miles northeast of San Jacinto, the fault branches. One zone continues to the southeast along the edge of Soboba sediments and extends to the Thomas Mountain fault; the other runs eastward along the northwestern end of the Soboba beds, then turns and passes through the sediments along the southeasterly course.

Several hot springs, including Relief, Soboba and those along Indian Creek, are found along this fault. North of Soboba Springs a minor branch extends into the granitic foothills to the northeast. A fault scarp occurs along the Hot Springs fault west of this branch.

Between Poppet and Indian creeks the fault zone is marked by a broad strip of rift topography, while farther to the southwest slumping and landslide scars mark the plane of movement at the surface.

Near Strawberry Creek the fault branches and re-branches and its trace is lost in the district north of Baldy Mountain. One and one-half miles south of Rayneta an area of hummocky hills with an occasional tree-surrounded spring indicates movements and disturbed rock masses. A southern branch extends across the valley and cuts into Baldy Mountain, where it is marked by mashed and slickensided rock.

Slickenside surfaces and crush zones in the valley south of the west end of Hemet Reservoir also mark the course of the Thomas Mountain fault. Crushed areas are found on the east side of Thomas Mountain, an exceptionally good exposure occurring at the saddle in the small spur west of B.M. 4503. Here the igneous rock has been mashed so badly that it appears as a friable arkosic mass.

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[36] Hill, Robt. T., Southern California geology and Los Angeles earthquakes, Southern Calif. Acad. Sci., Los Angeles, p. 35, 1928.

[37] *Op. cit.*, p. 37.

The Thomas Mountain fault follows the deep, steep-walled gorge of South Fork, San Jacinto River. Near the junction of this stream with San Jacinto River a crush zone shows up very well in the eastern wall of the canyon. From here the fault follows the present San Jacinto River valley closely and to the northwest passes under the alluvium of San Jacinto Valley.

The Bautista Creek fault roughly parallels the San Jacinto fault from a point near the junction of Bautista Creek and Horse Creek. A zone (rather than a sharply defined plane) of crushing and displaced strata marks the fault in the Horse Creek sediments. Southeastward from Horse Creek to the southern slopes of Thomas Mountain, depressed spur profiles and crushing indicate the path of movement. Many spurs along the foot of Thomas Mountain show good rift topography. These indicate more than one plane of movement, of which at least one continues into the Hamilton Creek district.

Movement along the San Jacinto fault zone probably occurred throughout the Quaternary and perhaps much earlier. Pre-Bautista movement is shown in the elevated erosion levels and by the fault-defined embayment of the San Jacinto Mountains in which the sedimentary beds of the Soboba district were laid down. Post-Bautista displacement resulted in the present position of the Bautista sediments above San Jacinto Valley.

Recent movement is shown in the topography by fault scarps, landslides, truncated spurs and fissures. Further justification of the statement of recent movement is found in the earthquakes of 1899 and 1918 which centered in this region.

The first of these quakes occurred on Christmas morning, 1899, and was described by the Riverside ''Press and Horticulturist'' of December 30, 1899, as occurring ''without any preliminary rumblings at 4:23 o'clock * * *. The undulations were from northeast to southwest and the temblor may be said to have been confined to the region lying between the mountains on the northeast and Perris in the opposite direction. The damage to the brick blocks was the same in nearly every instance. The south walls invariably went down, most of them falling outward * * *.'' It is interesting to note the statement of the movement of the undulations in a direction normal to the fault zone. This direction is substantiated by the falling southern walls of the brick buildings.

A second destructive quake visited the San Jacinto Valley on April 21, 1916. At this time buildings were destroyed and paved streets were cracked. Fissures appeared in the fields and along roads and landslides occurred in the Bautista sediments. The Los Angeles ''Times'' of April 23, 1918, states ''There were nine separate temblors over a period of thirty hours, beginning Sunday at 3:32 o'clock p.m.'' The shock was strong in the Thomas Mountain district. A resident of Hemet Valley, who was out in the field at the time of the shock, stated that it was quite severe in that region. Rocks were dislodged from the hillsides. Although this occurred along the side of Hemet Reservoir, the masonry dam at its western end suffered no apparent damage.

San Gorgonio Pass Fault Zone.

The San Gorgonio Pass zone of faulting lies north of the San Jacinto Mountains and extends east and west across the northern edge

of the area. It is located south of the San Bernardino Mountains and includes the southern extension of the San Andreas fault from Cajon Pass.

This fault enters the district in the upper part of Hathaway Creek Valley. It extends southeastward to the mouth of Stubby Canyon where it meets the Pass, thence running eastward through Painted Hill and continuing under the Coachella Valley sediments. The eastern part of this fault has an east-west trend paralleling that of the fault just to the south, which borders San Gorgonio Pass on the north. These faults have been described by Vaughan [38] and therefore will not be discussed in detail here.

A fault, named by Hill [39] the Lawrence fault, extends nearly east-west in the granitic foothills south of Banning. It follows the narrow, trough-like valley reaching from the northeastern edge of the red beds of the Mt. Eden formation to the divide just east of McMullen Trail. Crushed and slickensided granitic rock encountered along this valley locates the fault and explains the presence of the trough. The fault line is not so sharply marked in its eastern half, and here appears to have a wider fracture zone, which results in a broad depressed hilly district. At its eastern end the fault passes under recent alluvium of San Gorgonio Pass and at its western end under the sediments of Potrero Valley.

The faceted appearance of the north side of Cabezon Peak as well as the saddles in the two spurs west of Snow Creek indicate faulting, but no crush zones are found in the spurs. The saddles may have been formed by erosion along joints parallel to a fault lying to the north which is now covered by recent alluvium. The tip of Whitewater Spur east of Snow Creek is badly fractured and the schists and intrusive dikes show numerous small displacements. Here again there is no marked zone of crushing or slickensided surfaces and the chief plane of movement may lie a little further north. Brown [40] observed the crushed zone in the ridge south of Whitewater and thought that a fault there continued to the southwest through Palm Springs, accounting for the location of the warm-water springs at the latter place. It seems doubtful, however, if these two localities eight miles apart, one on the north, and the other on the east side of the mountain, lie on the same fault. The faults of the region as a whole occur in three zones, trending east-west, north-south, and northwest-southeast. The fracturing in Whitewater Ridge may be associated with the east-west zone of faults, while the phenomena at Palm Springs probably are associated with another zone.

From a study of the structures in the San Gorgonio Pass area, Vaughan [41] decided that the pass was a graben. This is not apparent from a brief survey of the present alluvium-covered strip. When it is considered, however, that the down-dropped block includes the lower San Bernardino foothills south of the San Andreas fault as well as the present Pass, the graben structure is more evident.

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[38] Vaughan, F. E., Geology of the San Bernardino Mountains north of San Gorgonio Pass. Univ. Calif. Publ., Bull. Dept. Geol. Sci., vol. 13, no. 9, Dec. 1922.

[39] *Op. cit.*

[40] Brown, John S., Fault features of Salton Basin, California. Jour. Geol., vol. 30, p. 217, 1922.

[41] *Op. cit.*

Palm Canyon Faults.

The faults of this region in places pass under fanglomerate deposits. Because these beds are not offset along the faults, the movement in this district is thought to have ceased earlier than did that in the zones of San Gorgonio Pass and San Jacinto. Planes of movement are marked by wide bands of crushed and intensely weathered rock. The largest of these faults extends down Palm Canyon and bears a little west of north. It passes under the alluvium of Palm Springs Valley where the trace is lost, although it may continue northward and supply the fracture along which the warm waters of Palm Springs rise. Opposite the mouth of West Fork, the fault lies in a small valley, a nearly parallel tributary of Palm Creek. Further south, the valley turns eastward, while the trace of the fault continues southward, where it is marked by clumps of palms, by crushed zones, and by tufa deposits.

Springs now existing along the fault determine the location of the palms, while the tufa deposits, which in places are 20 feet thick and cover hundreds of square feet, mark the position of ancient springs.

Several faults exist in the Murray Hill district east of Palm Springs Valley. They are marked by drainage lines and by discolored strips representing advanced weathering along the fractures and crush zones.

At least one of these faults is a thrust with the eastern side overriding the western. The plane of movement dips 45° or more to the east. It is best shown in a steep, cliff-like exposure of the schists one mile west and a little south of Murray Hill. This fault fades out to the south and on the north is truncated by a later, nearly vertical fault.

Structures of the Metamorphic Rocks.

The structures of the metamorphic rocks are due to metamorphism, batholithic intrusion and faulting. Metamorphism of the original sedimentary strata has disrupted them into numerous lenses. These have been tilted by the batholith at angles of 30° or more, and though they are not as a rule noticeably contorted, locally the crumpling is great. The schists of the Palm Canyon district are homoclinal, having a uniform eastward dip. Granite-gneiss, which is interpreted as a gneissic facies of the batholithic intrusion, cuts through the middle of this eastern metamorphic area. In its northern and central parts the gneiss parallels the structure of the altered sediments into which it was intruded. At the southern end, however, where the metamorphics curve southeastward around the Santa Rosa batholith, the gneiss locally cuts across their structure. Smaller lens-shaped bodies of this same gneiss are found lying apparently conformable with the schists east of Palm Canyon. The gneiss in general has sill-like relations to the schists. Apparently igneous material was intruded, as one larger and a number of smaller more or less tabular masses, into a thick series of schists. The smaller lenses vary from a few feet to a hundred or more feet in thickness, and outcrop along their strike for hundreds of feet and in some cases for a mile or two. Where they have entered along limestone layers there has been noticeable silification of the carbonate rock.

At the San Jacinto divide the schists dip eastward at angles of 40° to 70°, but near Palm Creek the average dip is 35°. The steeper dip

is thus closer to the batholithic contact, with diminishing dips along the flanks. The schists have apparently been intruded by the subjacent batholith, elevated, and tilted. Near the crest of the mountains the contact is very sharp, with only a few feet, or in some cases with only a few inches, of gradational material. Here, as at other places where the granite of the batholith is in contact with the schists, little difficulty is experienced in fixing a definite boundary line, but where it adjoins the gneiss (for example near Andreas and Tahquitz creeks) there is no sharp break and the contact is indefinite. Near Andreas Canyon the gneissic nature of the rock below an elevation of approximately 2000 feet is noted. On the slope below Tahquitz Valley the batholithic granodiorite is easily traced to an elevation of approximately 3500 or 3000 feet. Between these limits is a rock representing the zone of gradational material lying between the purer magma core and the bordering gneissic rock. Small schist xenoliths are included in this zone, showing that schists were probably not far above the present erosion surface.

Several stock-like projections of the batholith pierce the schists west of Palm Canyon, forming igneous islands. Farther north small patches of schists lie within and at the edge of Tahquitz Valley. The largest of these, at the eastern edge of the valley, is probably a roof pendant, for its structural lines are oriented parellel to those of the schists just to the south.

The presence of these small schist areas give a clue to the origin of Tahquitz Valley. The erosion which resulted in the present valley was in schistose as well as in granitic rock. The latter is found on both sides of the valley hundreds of feet above the schist patches. There is probably a structural depression in the upper batholithic surface at this place which may be in part responsible for Tahquitz Valley.

South of Whitewater a metamorphic spur extends northeastward into San Gorgonio Pass. The schists of this ridge dip northeastward with an average inclination of 30° to 40°. Dips of 60° are found in places. In the lower part of this spur the rocks are badly fractured and disturbed. To add to the confusion, intrusive dikes of two stages are found.

The Dellamont-Claremont schists dip at high angles southwestward to the edge of the San Jacinto Valley, where they are truncated by a great fault. The smaller areas isolated by the later sediments dip northeastward. This indicates a former continuous anticlinal structure in the metamorphics, with probably a bulge in the batholith beneath.

A similar anticlinal structure occurs on Coahuila Mountain, where the schists dip away from the crest-line along which the granodiorite of the Coahuila stock is occasionally exposed.

An interesting igneous member (gabbro) in the metamorphics is found in the Oak Mountain district in the southwestern part of the quadrangle. This basic intrusive shows rude gneissic structure. On the northeastern slope of Oak Mountain the contact with the granodiorite was found and injected tongues of the latter were examined. There is no doubt that the gabbro is the older. The exact line of contact with the schists to the east, however, was not definitely determined, and it was only after dikes of similar rock were found on Coahuila Mountain that the intrusive relation of the gabbro was suggested. On the south slope of Coahuila Mountain as well as on the southeastern

ridge of Thomas Mountain, dikes of this basic material were found cutting the schists. The Coahuila Mountain location is of special interest. Here a large tourmaline-rich pegmatite dike cuts the metamorphic rocks. This dike, which is 35 to 40 feet in thickness at one place, had a 12-inch inclusion of the basic dike. The latter, in turn, is later in age than the schists which it intrudes.

Structures of the Batholithic Rocks.

Certain of the contact relations of the batholith and several of its small stocks have been described.

Long before the San Jacinto block was raised between its fault planes to the north and south, a magma forced its way toward the surface. It entered the older rocks, tilting and arching them in its vicinity and finally cooled, to form a steep-sided, irregular granitic mass. Part of the intruding mass entered as lenses between the layers

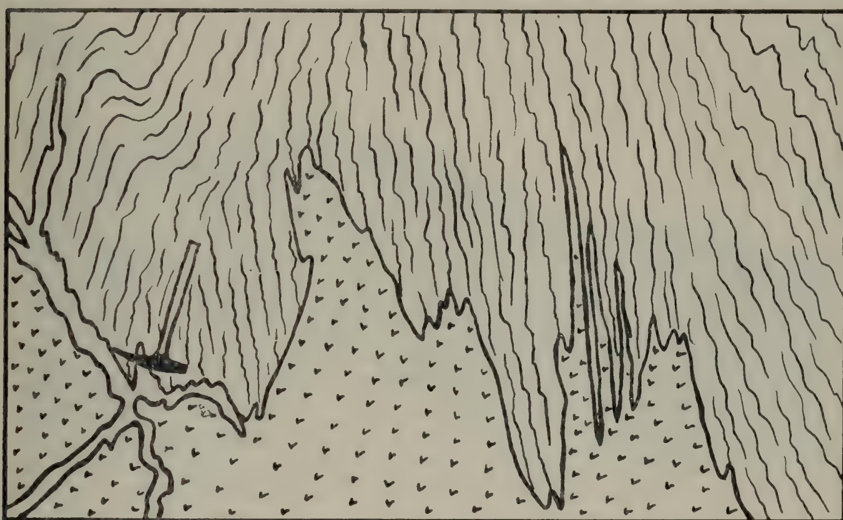


FIG. 17. Sketch from a photograph, showing pegmatite dike (located by hammer) formed along contact of granite (below) which intrudes schist (above). Locality, Coahuila Mountain.

of the overlying schists. These tabular bodies developed flow lines and gneissic structure as they solidified in an area suffering dynamic stress as a result of magmatic movements.

Certain irregularities of the batholithic mass are worthy of attention. The arc-shaped ridge to the northwest of the higher peaks, the relatively flat Round Valley, fringed with peaks, and Tahquitz Valley are all thought to owe their present form at least in part to the original upper surface of the batholith.

As would be expected in an area of large faults along which there has been an aggregate movement of thousands of feet, there are numerous joints. Lily Rock south of the higher San Jacinto Peaks has a well-defined joint system. One set dips southwest at 70° and strikes northwest-southeast. It is cut by sheet joints or exfoliation layers which dip northward.

Two miles northeast of Hemet Reservoir there are joints in the rocks which lie parallel to an indistinct gneissic streaking of the granodiorite. They strike N. 10° W. and dip westward, 60° or more. Near the junction of South Fork, San Jacinto River and the San Jacinto River proper, there is a joint system which strikes N. 40° E. and dips southeast 35°. In the igneous area on the south side of Coahuila Mountain the dominant joint system dips south at 75° to 85° and strikes east-west. This system was largely responsible for the steep cliff face of the mountain on the south.

Structures of the Later Sediments.

In each of the several sedimentary areas the dominant structure is a homoclinal dip to the north or northeast.

Potrero Valley lies on the truncated edges of the sandstones and grits of the red bed member of the Mt. Eden formation, which dip

FIG. 18. Exposure of Bautista sediments of the Soboba area, near mouth of Indian Creek, showing local unconformity.

northward at angles of from 10° to 20°. To the south these sediments extend up to the northern slopes of Dellamont-Claremont, where their dip increases slightly.

These coarser sediments have a depositional contact with the metamorphics and the igneous rocks below them. To the northwest they conformably underlie the Mt. Eden beds, fine-grained, more friable strata which extend northwestward.

Both the Mt. Eden beds and the red bed member are broken and faulted. This has caused considerable variation in the dip and strike of the beds. Near the irregular contact line between the two, somewhat different strikes are found, and it is only after tracing the contact into several of the steep-walled canyons that conformable relations were established.

The Mt. Eden formation as a whole is badly broken, not because major faults pass through its area, but because it lies between two extensive fault zones.

The Bautista beds of the Soboba area in general strike northwest-southeast, roughly paralleling their line of contact with the batholith. Large faults, faults of minor movement, slides and slumping have contributed to the present confusion of the beds. No folding was observed; opposing dips apparently result from faulting, not bending, of the beds.

Prolonged intermittent movement in this region has caused to take place in the weaker rocks, often followed by land slides. Exposures of these features exhibit what appears to be local unconformities. Frick [42] cited an angular unconformity at the mouth of Poppet Creek and suggested that it was "merely an exceptional example of the general disturbance."

During the winter of 1927 flood waters in San Jacinto River cut into the southern edge of the sediments of the Soboba region, forming fresh exposures at many places. One of the best of these occurs in the northern bank of the mouth of Indian Creek. At this place a clean section, 30 feet in height, is exposed. The lower 15 feet of friable blue-gray sandstone and shale dip 10° to 18° in an east-southeast direction. These are overlain by loosely consolidated conglomerate and sandstone which dips S. 10° E. at an agle of 8°. Both formations are covered by several feet of sandy soil, washed down from the slopes. The upper formation which has gravel layers at its base is not badly broken but seems to have been deposited in layers by water. At a few places small displacements noted in the lower formation did not continue into the overlying beds. These conditions point to two periods of deposition rather than to slumping.

The sediments of the Bautista area strike northwest-southeast and dip northeast, with an average dip of approximately 20°. It has been suggested [43] that these beds occupy a broken fold, but the rather uniform northern dip of the beds would indicate a homoclinal structure.

An interesting Bautista-granite contact occurs one mile east of the mouth of Rouse Creek. At this point, a northern tributary entering the main stream has cut deeply into the sediments, and close to its mouth has reached the granite upon which the sediments were deposited. Only six feet of granite were exposed in the canyon wall. This granite was deeply weathered and did not differ greatly, except in lack of stratification, from the overlying arkosic material. The granite showed a beveled surface, indicating leveling by weathering and erosion before deposition. Here again is evidence of the northward tilting of this block.

PETROLOGY

Granite.

The granite of the San Jacinto batholith is a massive, light gray, granitoid rock in which porphyritic varieties are absent. The chief variation consists of differences in the percentages of orthoclase, plagioclase and quartz, and minor differences in texture. Therefore no striking changes in the character of the batholithic rock can be observed in the field, but when thin sections of specimens from many localities

[42] *Op. cit.*
[43] *Op. cit.*

were examined several different facies were recognized [44]. Seventeen specimens were classified as follows:

Granite	3
Quartz monzonite	2
Granodiorite	3
Quartz diorite	9
Total	17

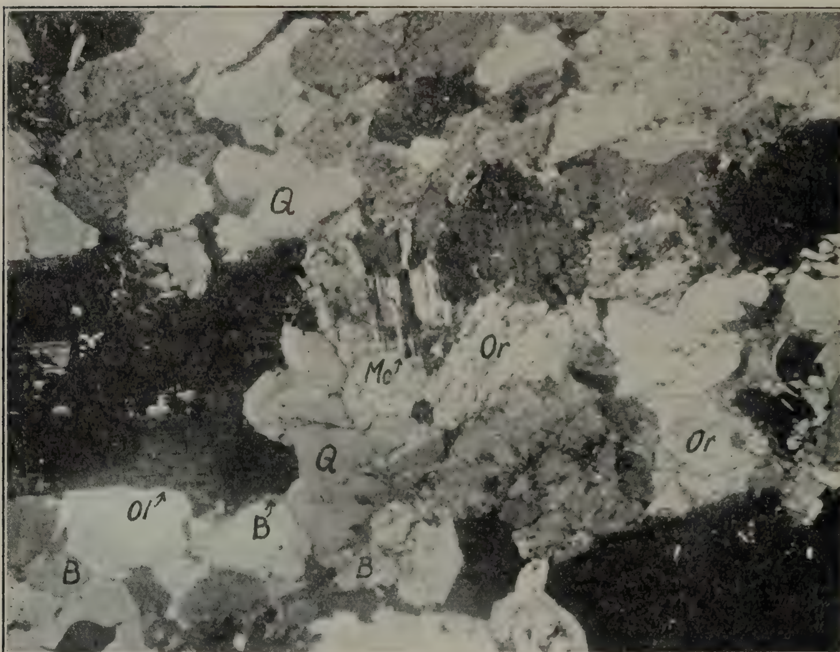


FIG. 19. Photomicrograph of granite specimen (F-49), showing orthoclase (Or); quartz (Q); microcline (Mc); oligoclase (Ol); and biotite (B). Note the granitoid texture and crushed grains. Magnification 23 diameters.

Petrographic description: Specimen F-49, from the ridge back of Cabezon Peak, is a true granite. Under the microscope the texture is finely granitoid and the original massive structure is disturbed by numerous fractures. Practically every grain of quartz and feldspar is fractured, but there has been little or no displacement and the rock has maintained a typical granitic appearance. Much of the quartz and

[44] Edwin T. Hodge's Rock System was used in the classification of these rock types. "A Proposed Classification of Igneous Rocks." Univ. of Ore. Publ., vol 2, no. 7, Nov. 1924.

feldspar shows strain shadows, and, in addition, many plagioclase grains show discontinuous twinning bands. The following minerals were determined:

	Percentage
Orthoclase, Microcline, Perthite	65
Albite	2
Oligoclase	8
Biotite	8
Quartz	15
Apatite (accessory)	T
Sericite (secondary)	1

The percentages given in the table above and in similar ones to follow are only approximate. They were obtained by estimating the percentages of minerals in 10 to 25 'fields' of the thin section. Consequently, the figures, though not accurate, give a rough idea of the relative abundance of minerals in the specimen.

Orthoclase, microcline and perthite occur as anhedral grains scattered throughout the rock, orthoclase appearing in places as interstitial material. Larger grains of microcline contain inclusions of quartz, biotite and oligoclase and often have elongate projections which extend between adjoining mineral grains into the adjacent rock mass. The oligoclase inclusions are often bordered by small amounts of albite and the biotite inclusions have small scales of muscovite along their edges. Oligoclase occurs in subhedral and anhedral grains which are often speckled with sericite flakes, being similar to orthoclase in this respect. Biotite grains in the main body of the rock are subhedral and somewhat smaller than the average grain size. They are not numerous and are well scattered, and some show alteration effects along their edges from which muscovite resulted. Quartz is always very irregularly anhedral and practically every grain shows pronounced fracturing. In a few places small vermicules of quartz are intergrown with oligoclase and form myrmekite. These areas are usually along the margin of orthoclase or microcline grains. Apatite as an accessory mineral is found as occasional small rounded grains. On the whole, this rock is quite fresh and unaltered.

Granite facies of the batholith occur also at the crest of the divide between Strawberry and Tahquitz valleys and at the Hemet Bell mine near Kenworthy.

Three and one-half miles north of Point View, the San Jacinto batholith has a granodioritic composition. A specimen (F-27) taken from this district has a light gray color and a massive structure. The thin section shows an equigranular granitoid rock with numerous distinct fractures. Strain shadows are common in quartz and appear to

a smaller extent in feldspar grains. The rock has the following minerals, the estimated percentage of each being given:

	Percentage
Oligoclase	55
Orthoclase / Microcline	15
Quartz	15
Biotite	10
Hornblende	3
Apatite (accessory)	1
Titanite (accessory)	1
Magnetite (accessory)	T
Sericite (secondary)	T
Epidote (secondary)	T

As this table indicates, the major part of the rock is made up of oligoclase-andesine, which occurs as subhedral and, to a lesser extent, as euhedral grains. Most of the orthoclase and all of the microcline present is found as interstitial material; orthoclase occurring as slender ramifying arms which separate and, in places, penetrate other grains of the rock. Quartz is anhedral and is badly fractured; biotite is subhedral to anhedral, is quite fresh and shows strong pleochroism, with X—golden yellow, Y—brownish green and Z—dark brown to opaque. Hornblende occurs chiefly as well-formed crystals and also shows strong pleochroism with X—golden yellow, Y—brownish green and Z—dark green. Both biotite and hornblende contain inclusions of titanite and apatite.

Except for the fractures, the rock is remarkably fresh and unaltered. Only occasionally are small patches of sericite and little grains of epidote encountered. There are a very few small patches of myrmekite which are always associated with interstitial orthoclase.

Granodiorite or quartz monzonitic facies of the batholith occur in the low foothills west of Banning, at an elevation of 10,000 feet; on the eastern slope of San Jacinto Peak, and at the eastern base of Roundtop.

A typical specimen (F-163) of quartz diorite from the southeastern side of Thomas Mountain near the edge of Hemet Valley is light gray, massive and in texture medium granitoid. In the hand specimen, it appears quite similar to the granites and granodiorites mentioned previously, but in thin section the differences in the feldspar and in mineral percentages are established. The minerals and their approximate percentages are as follows:

	Percentage
Oligoclase-andesine	55
Quartz	30
Biotite	10
Orthoclase	4
Apatite (accessory)	T
Chlorite ((secondary)	T
Muscovite (secondary)	T

Here, as in the previously discussed rocks, the plagioclase grains are subhedral and show strain shadows and discontinuous twinning

bands. Quartz is entirely without crystal form, is very irregular, shows strain shadows and (like the feldspars) is noticeably fractured. Biotite is very patchy and occurs in irregular flakes. It shows pronounced pleochroism with X–yellow, Y–yellow brown and Z–red brown. Orthoclase occurs as interstitial material, characteristically appearing as irregular elongate areas between other mineral grains and in places penetrating plagioclase and biotite.

At a few places in the section, groups of small elliptical patches of quartz occur within the limits of oligoclase-andesine crystals. These are always found in proximity to some of the small, irregular, scattered, interstitial patches of orthoclase or else are associated, within the plagioclase crystal, with small amounts of orthoclase.

Interpretation and conclusions: The equigranular, granitoid texture of these rocks indicates uniform conditions of consolidation. Except for the very small amount of albite, the last mineral to crystallize was orthoclase or microcline, for these minerals have numerous fringe-like projections reaching between earlier-formed grains and in many instances they completely surround these older minerals. Similar relations were observed in a number of sections, the interstitial mineral in each case being one of the two mentioned above. The presence of albite rims around some of the feldspars and the myrmekitic intergrowths indicate a minor amount of end-stage activity. On the whole, however, the rock is relatively free of end-stage or secondary changes and has had a rather simple history.

The conclusions arrived at from observations of the thin sections just described, as well as from similar microscopic observations of 14 other specimens of the batholithic rock, are listed below.

1. The San Jacinto batholith, composed of granite, is not a true granite throughout. It has granite, quartz monzonite, granodiorite and quartz diorite facies and probably has an average composition close to that of a basic granodiorite.

2. The granite was formed from the cooling of a molten mass of igneous rock of rather high silica content. A marginal phase of the granite, as a result of cataclastic and protoclastic processes, developed gneissic structure. This phase will be discussed later as the Andreas gneiss.

3. The main magma which formed the batholithic rock had a rather simple crystallization history—among the primary minerals biotite and plagioclase formed, then quartz, which was followed by orthoclase or microcline or both, and here and there small amounts of albite.

4. End-stage or deuteric effects were not pronounced and were limited to the formation of small amounts of myrmekite and minor albitic attack.

5. The rock has suffered considerable dynamic stress as is indicated by the fractures and strain-shadows, but weathering changes are lacking and a fresh appearance is the rule.

Granite-Gneiss.

Except for its gneissic structure, this formation is very much like the Tahquitz granite. The mineral assemblage is the same and the texture is similar, though usually finer in the gneiss. The streaking and massive bedding, however, are usually well marked in the gneiss and serve to distinguish it from the typical igneous rock of the batholith.

As has been previously stated, on approaching the batholith the gneiss changes in appearance by the loss of the distinct heavy beds, and by gradation it passes into the granite of the higher slopes.

Petrography: Microscopical study of specimens of the granite-gneiss taken from six different localities revealed a number of items of interest. These include mineral assemblage, texture, structure and genesis, and offer proof of the conclusions to be drawn later. As the features of each specimen are usually shown to a greater or lesser degree in the others, they will be discussed as a unit. In the table below the specimens and their locations are given.

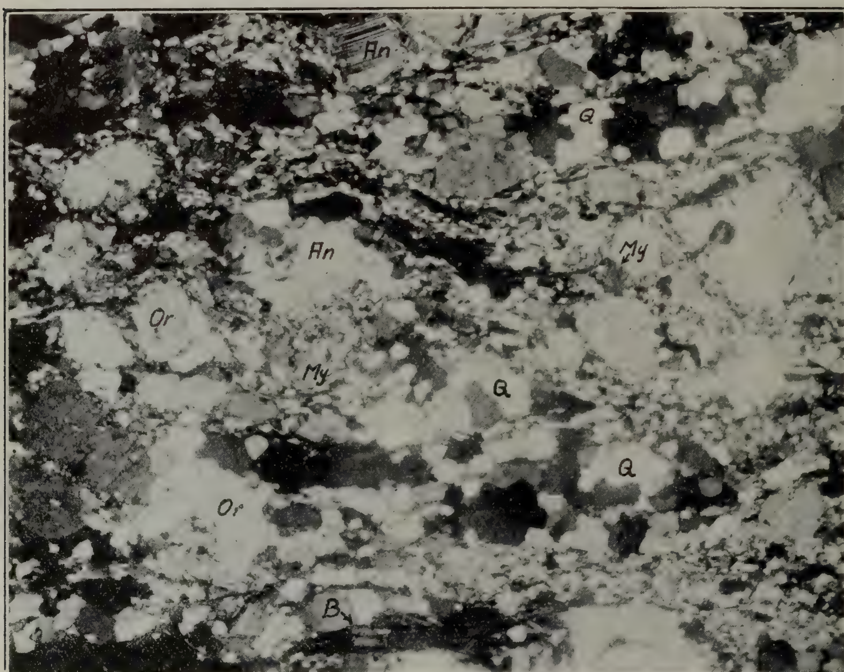


FIG. 20. Photomicrograph of granite-gneiss specimen (F-204), showing oligoclase-andesine (An); quartz (Q); biotite (B); orthoclase (Or); and myrmekite (My). Note: crushed areas and elongated biotite grains extending from left to right. Magnification, 23 diameters.

F– 19.	South wall of Chino Canyon at edge of Palm Springs Valley.
F– 41.	Along the stream in Palm Canyon, at an elevation of 1500 feet.
F– 46.	Crest of ridge south of Tahquitz Canyon, at an elevation of 3000 feet.
F– 47.	Crest of ridge south of Tahquitz Canyon, at an elevation of 3200 feet.
F–128.	Andreas Canyon road, at an elevation of 700 feet. (One-half mile north of the mouth of Andreas Canyon.)
F–204.	Crest of ridge north of Andreas Canyon, at an elevation of 1600 feet.

Texturally, the granite-gneiss ranges from finely granitoid to moderately granitoid. The structure is dominantly gneissose, with an occasional granulose variation. The minerals are:

Oligoclase or oligoclase-andesine.
Quartz.
Orthoclase.
Biotite.
Apatite (accessory).
Myrmekite (end-stage).
Muscovite (secondary).
Sericite (secondary).
Epidote (secondary).

Plagioclase is always the most abundant component, quartz next, then orthoclase and biotite. Apatite appears as a few small scattered grains and the secondary minerals occur in very small amounts. Myrmekite is present in all of the sections.

The proportion of fine-grained crushed material to larger grains in the granite-gneiss is variable. Usually, however, the larger grains occur in indistinct bands in which the individual grains are more or less separated by the crushed material. Plagioclase is always fractured and has broken edges. The grains are oriented with their long dimension parallel to the gneissose structure but have not been crushed and elongated to as great a degree as has quartz. Quartz has been so badly broken and disturbed that it usually occurs as elongate mosaic areas. Strain shadows are common in both quartz and feldspar. Orthoclase grains are fractured but not crushed. Their edges have been ground away and they are oriented with the rock structure. Whereas individual quartz areas are formed of a number of smaller interlocking grains, the larger feldspars are usually the uncrushed remnants of original single crystals. Biotite is scattered throughout the rock. It appears as larger flakes which have been deformed around feldspar or quartz grains; as aggregates of small flakes drawn out parallel to the gneissose structure; as borders around larger mineral grains; and as fine flakes in the fine-grained crushed material. It shows strong pleochroism, with X–golden yellow, Y–red brown, and Z–dark red brown to opaque.

The crushed material is composed of an intimate mixture of small grains of orthoclase, plagioclase, quartz and biotite from one-tenth to one-hundredth of a millimeter in diameter. A few scattered grains of apatite are present and here and there small patches of muscovite or a few sericite flakes and an occasional epidote grain are found. Myrmekite occurs in orthoclase crystals as encroachment areas and also in the fine-grained crushed material. This dual occurrence is important and is later discussed more fully.

The gneissic appearance of the rock is due to (a) layers richer in biotite, (b) varying texture in which alternate indistinct layers of fine and coarse material are present and (c) elongation and orientation of quartz and feldspar grains.

The gradation of the granite-gneiss into the granite, as observed in the field, has been mentioned elsewhere. In thin sections, the gradation is more interesting. As the granite is approached, the gneiss changes by decrease of finely crushed material and by increase of uncrushed

grains which are grouped close together. As these groups become more numerous the gneissic banding or streaking gradually fades and a granite results.

Interpretations and conclusions: Among the smaller structures, the myrmekitic intergrowths are the most interesting and important. Myrmekite is an intimate mixture of plagioclase and vermicular bodies of quartz, found usually on the borders of orthoclase or microcline grains. Within the granite-gneiss, myrmekite developed around such grains and also in the fine-grained groundmass. In the latter case, it was not always possible to find traces of orthoclase, but it is thought that orthoclase was once present and has been entirely replaced. A few myrmekitic intergrowth areas were observed to occupy almost the entire space between neighboring larger grains of feldspar. Had these intergrowths developed prior to the period of major movement of the rock mass, they would have been fractured and mashed by the later distrubance. If they formed later, we should expect myrmekite in the groundmass as well as around larger orthoclase grains. These areas are found. Whether they developed as an end-stage or final-consolidation phase intergrowth or as a result of introduced material of a later phase than the final consolidation of the magma is of importance. In the latter case, myrmekite would be expected in continuous or nearly continuous streaks or in closely associated patches and most of the larger orthoclase grains would be unaltered. However, the myrmekitized orthoclase grains are distributed at random and not all orthoclase grains have been attacked. Likewise, myrmekite in the finer-grained areas is patchy and discontinuous. There seems to be no good evidence for supposing that the myrmekite is of a later age than the final consolidation of the original magmatic material.

The alternative theory—that the myrmekite is the result of end-stage or final-consolidation phase intergrowth—would mean that the present gneissic structure had developed by that time, or in other terms, that the granite-gneiss is a protoclastic rather than a cataclastic rock. It may have been a primary gneiss at some stage before its final consolidation, but if, as has been stated, the myrmekite is an end-stage product, movement with crushing and parallel orientation of grains must have been very active previous to final consolidation and therefore protoclastic structures are now dominant.

That movement and crushing did occur before final consolidation is proved by the structural relations of several grains of plagioclase observed in specimen F–46. Here oligoclase crystals have been fractured, the fragments only slightly displaced, and the fractures healed by fine-grained mosaic aggregates of material not wholly composed of oligoclase fragments, hence they can not be entirely the result of crushing. These small veins might have originated in one of the following ways:

1. After the final consolidation of the rock—
   a. Through crushing and the rolling of small grains into the larger fractures.
   b. By introduction of vein material from without the immediate rock mass.
2. Before or at about the time of the final consolidation of the granite-gneiss, by fracturing and healing by remaining solutions.

The first of these processes may have been possible, but it seems unlikely that dynamic movement alone could result in the crushing of oligoclase grains, the partial separation of the fragments and the development of veins of feldspar and quartz between the component parts. Even if solutions were introduced and the veins were of a later age as indicated in 1-b above, they should be continuous and not limited to a single large crystal and its immediate surroundings. If, however, the oligoclase grain had been fractured in a nearly solidified mass, it could easily have been healed by the entrance of some of the residual solution of the rock mass and thus have given rise to the structure observed.

Final consolidation of the rock must have followed most of the fracturing; that is, it followed the development of the gneissic structure. More recent dynamic movements which fractured the rocks of the region in an intimate manner had no effect on the development of gneissic structure because specimens of the gneiss exhibiting equal fracturing show marked differences in the perfection of gneissic structure.

From the structural relations shown in the field and the information obtained from thin sections, it is concluded that the granite-gneiss is a phase of the granite. The minerals are identical in many specimens; the textures are almost the same; the gneiss grades into the granite and both show intrusive relations to the older schists. A summary of the events leading to the formation of the granite-gneiss is given below as follows:

1. The entrance into, and the tilting of the Palm Canyon schist by the magma (granite and granite-gneiss). When the magma entered the schist it formed a marginal phase along its eastern edge. This phase of the granite developed gneissose structure as a result of the movements outlined below, and gave rise to the granite-gneiss.
2. Cooling and crystallization of the magma, with the continuation of movement in the still liquid magmatic mass, accompanied by movement of more or less isolated parts of the margin of the magma; as, for instance, that part having sill-like relations which makes up the southern end of the granite-gneiss exposure.
3. Later stages of crystallization of the granite-gneiss, accompanied by—
    a. Movement continuing as a result of adjustments in the main magma to the west which caused fracturing and crushing of previously formed minerals.
    b. Development of myrmekite and end-stage albite in final consolidation stage along the borders of orthoclase grains, as interstitial material, and in the groundmass of crushed material.
4. Dynamic movement affecting the entire area at a definitely later period than that during which the above events took place. Faults were developed and extreme fracturing of rock masses and cracks and strain shadows in mineral grains resulted.

Metamorphic Rocks.

The oldest rocks of the region are composed of a great thickness of undifferentiated gneisses and schists which have been formed by the metamorphism of both igneous and sedimentary rocks. Among the types which are found are quartzo-feldspathic gneisses and schists, hornblende schist, phyllite, crystalline limestone, and quartzite.

It is not the object at this time to discuss in detail all the rock types encountered in this series of metamorphic rocks. Only a few characteristic specimens will be described, in order to make clear the discussion of the metamorphic agents and processes which resulted in the formation of this series of rocks. The point of primary interest regarding the schist series is its petrology, or natural history, not its petrography, or textural and mineralogical make-up. The study of the latter, however, is a necessary prerequisite of the understanding of the former. Consequently, a description of a few members of the schist series follows:

Petrography: A xenolith of schist occurs in the granite near the mouth of Bull Canyon at the southern end of Hemet Valley. It is composed of feldspathic-biotitic gneisses and schists but it also contains a small feldspathic-hornblende schist member. This unit specimen (164) is a dense, black, heavy rock which under the microscope is moderately fine-grained and has a rude schistose or finely granulose structure. Marked schistosity is lacking because the hornblende grains, though usually oriented with their C-axes parallel, fall considerably short of the requisite 5:1 index of elongation of hornblende in schist.

Hornblende and andesine in about equal amounts make up most of the specimen. The grains of the former are only slightly longer than wide and in general have an equi-dimensional appearance. All are fractured and some have small inclusions of magnetite and apatite. In places, hornblende and andesine are interlocked in mosaic patterns. The former occurs in larger grains and is somewhat more abundant. The equant grains of andesine are fairly clear but contain some mineral grains and occasional magnetite and apatite inclusions. There are no secondary alteration effects.

A feldspathic schist containing hornblende and biotite (F-77) found along the San Jacinto divide at the headwaters of West Fork, is finely-speckled, grayish and shows rude schistosity. In thin section, it is fine-grained, has a structure which is between schistose and granulose, and is composed of andesine, quartz, hornblende and biotite in about equal amounts, with scattered small grains of magnetite and apatite. All of the grains are fractured and are close to the same size. Even the hornblende and biotite are not elongated but are scattered throughout the rock in more or less equant grains which results in a near-granulose structure. The pleochroic formula of hornblende is X—green yellow, Y—brown green and Z—green; of biotite it is X—yellow, Y-Z—red brown. The grains are irregular in shape and interlock with each other as well as with quartz and andesine. The andesine shows cleavage lines but is commonly untwinned. Quartz is clear and usually occurs as equant grains of irregular outline. Fine needles of apatite are scattered throughout the rock, as inclusions in the other minerals. The specimen is fresh and there is no evidence of secondary alteration.

A fine-grained, grayish phyllite (F-240) occurs near the southern end of the large schist area west of Palm Canyon. It is cut by joints which form blocks having rude rhombohedral shapes. No minerals could be determined in the hand specimen.

In thin section, under the microscope, the rock is very fine-grained. The minerals are sericite, quartz, feldspar and epidote, the grains of each, except quartz in the elongated lenses are disseminated through the rock and can be identified only by using high magnifications. Two major structures are shown—one consisting of fractures and elongate lenses of small quartz grains parallel to the original bedding, and a second composed of small flakes of sericite having an echelon arrangement which form irregular planes cutting the quartz lenses at angles of 25° to 30°. As the section was not cut normal to the line of intersection of these two structural planes, the true angle, which is close to 50° in the hand specimen, is not shown. In plane polarized light, the original bedding is shown by wavy bands of clouded material which curve around the occasional larger grains. Between crossed nicols these bands disappear but the quartz lenses mark the bedding planes and the staggered sericite flakes follow the planes of false cleavage.

Interpretation and conclusions: In general, the rocks described above have been metamorphosed by the recrystallization of materials already present, and have not had new material introduced. Usually only one period of recrystallization is indicated, and the minerals, with the exception of certain of the limestones, are few in number and are the common rock-forming ones. The bulk of the metamorphic rocks are composed of quartz, feldspar, biotite, hornblende and muscovite. This assemblage of minerals is so typical of granitic rocks that the original rock may be at first assumed to have been igneous. Such an assumption is certainly in error in many cases, for the presence of crystalline limestone and quartzite is conclusive proof of the sedimentary origin of some of the layers. If the sediments were arkosic or quartz-feldspar sands, however, the altered rock would appear much as an altered granitic rock and might thus be erroneously classified. For this reason it is impossible to correctly relegate the quartzo-feldspathic-biotite gneisses to a former igneous or sedimentary origin.

For the reasons discussed below it has been concluded that the metamorphic series was formed by dynamo-thermal metamorphism. It is unlikely that heat alone could produce such large areas of metamorphics; if accompanied by solutions or emanations, there should be evidence of introduced materials or of additive processes.

The minerals that occur in the metamorphic series are characteristic of dynamo-thermal rather than of plutonic, thermal, or hydrothermal metamorphic processes. Hornblende is present rather than pyroxene, or chlorite and epidote; oligoclase rather than albite or saussurite; biotite rather than chlorite or epidote, calcite and quartz. There is an absence of minerals usually found in rocks resulting from plutonic or thermal metamorphism.

Specimen F-164, which at present is quite simple, was formed by the dynamo-thermal alteration of a sill-like intrusive of andesitic or diabasic composition. Pyroxene or hornblende, plagioclase and a little magnetite, were very likely the original minerals. It is difficult to say from what rock F-77 has been derived, but in all probability it was

formed from an igneous rock of granodiorite or diorite composition. The original material of F-204 was a silt rock or shale. Slate may have first resulted from the metamorphic agents of heat and pressure and later, under the action of reorganization and recrystallization of the component particles, changed to the present phyllite.

Summary: The metamorphic rocks comprise a series of old sedimentary and igneous rocks now greatly altered. They were changed by dynamo-thermal metamorphism. The characteristic minerals are quartz, oligoclase or oligoclase-andesine, hornblende and biotite. The rocks, therefore, are usually quartzo-feldspathic gneisses and schist. Gneissose and linear schistose structures prevail. Fresh rocks showing little or no weathering are the rule and no definite evidence of a former

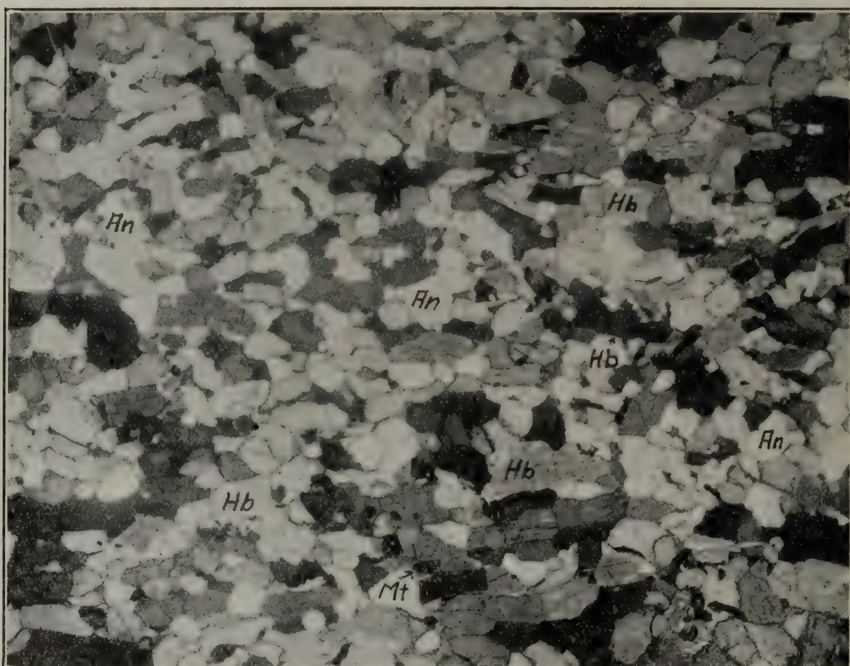


FIG. 21. Photomicrograph of a specimen of hornblende-schist (F-164), showing hornblende (Hb); andesine (An); and magnetite (Mt). Note the schistose structure in which hornblende grains are oriented with their long axes parallel to the base of the picture. Magnification, 23 diameters.

higher grade of metamorphism with subsequent retrogression, or diapthoresis [45], was obtained.

GEOLOGIC HISTORY

Summary of Events.

The earliest geologic event recorded in the region of the San Jacinto quadrangle was the deposition of sediments. These consisted of sandstone, shale and limestone and are thought to have been laid down during early Paleozoic or pre-Paleozoic time. Probably over

[45] Knopf, Eleanora Bliss, Retrogressive metamorphism and phyllonitization. Am. Jour. Sci., vol. 21, Jan. 1931.

10,000 feet of sediments accumulated in the area which then must have been a depressed district.

These beds were intruded by acid and basic igneous rocks and then metamorphosed, so that they form at present several thousand feet of lenticular beds of gneiss and schist.

Near the close of the Jurassic a granitic magma, which at depth may have contained a major source of energy for the alteration of the older rocks, entered the schists and gneisses. The magma developed a gneissic phase along its eastern edge as a result of continued movement during consolidation. The main body of the magma, however, tilted the schists and then cooled resulting in the formation of the granite of the San Jacinto batholith.

Erosion followed and was active over a long period of time. Then faulting occurred which later resulted in the uplift of the San Jacinto block. Though there is no evidence of the exact geologic age of the faulting, it may have started during the early Tertiary.

Mt. Eden beds overlying the red bed member of the Mt. Eden formation deposited during the late Lower Pliocene. To the west of this quadrangle, Upper Pliocene sediments unconformably overlie the Mt. Eden formation but in part of the San Jacinto region, herein described, they are absent; the next youngest sediments are of Pleistocene age.

Pleistocene and recent fault movements have elevated the sediments above the present San Jacinto Valley, and the faults are still active.

The sequence of geological events is roughly as follows:

1. Deposition of sediments (Paleozoic or older).
2. Older intrusions.
3. Dynamo-thermal metamorphism.
4. Basic intrusions.
5. Granitic invasion (Jura-Cretaceous).
6. Faulting—continuous to the present time.
7. Mt. Eden red bed member deposition (Miocene ? or Pliocene ?).
8. Mt. Eden deposition (Pliocene).
9. Bautista deposition (Pleistocene).
10. Recent alluvial deposition.
11. Faulting—continuous from a time antedating the deposition of the red beds of Mt. Eden formation.

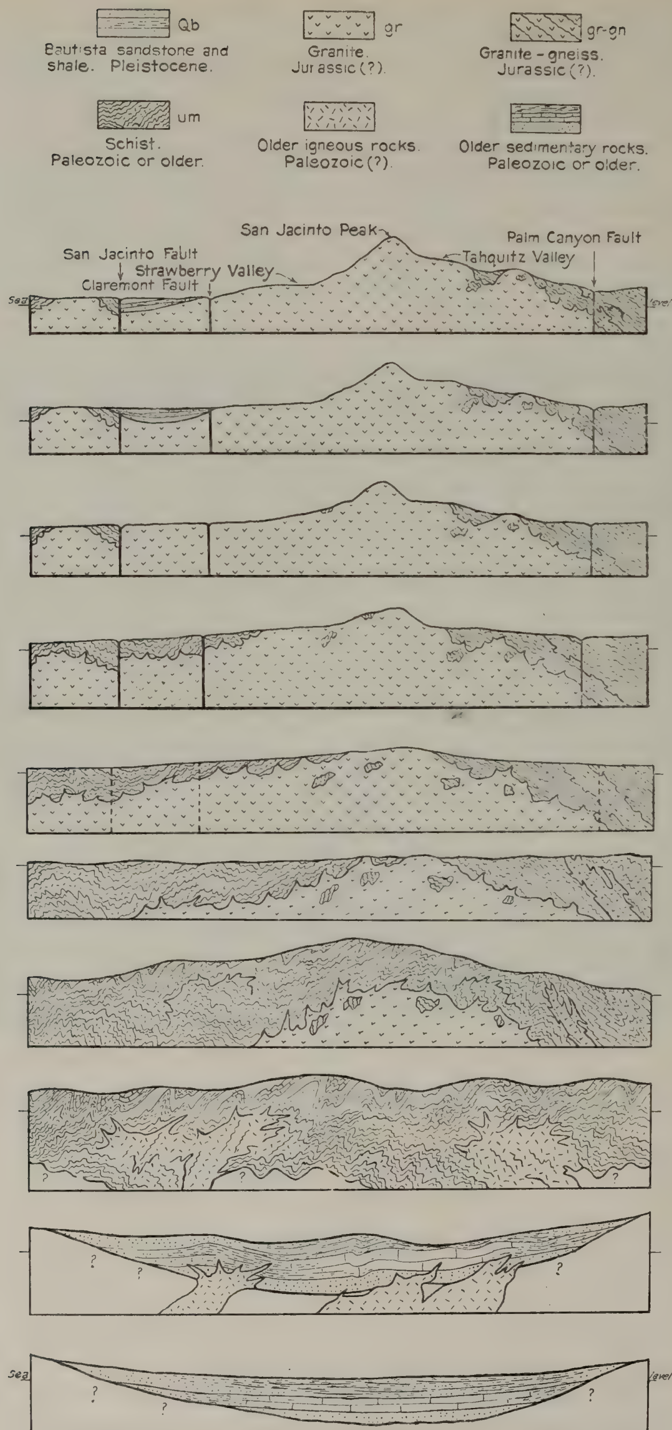

Qb
Bautista sandstone and shale. Pleistocene.
gr
Granite. Jurassic (?).
gr-gn
Granite - gneiss. Jurassic (?).
um
Schist. Paleozoic or older.
Older igneous rocks. Paleozoic (?).
Older sedimentary rocks. Paleozoic or older.
San Jacinto Peak
San Jacinto Fault
Strawberry Valley
Claremont Fault
Tahquitz Valley
Palm Canyon Fault
Sea
level

FIG. 22. A series of sketches showing an east-west structural section through the San Jacinto Mountains. The uppermost indicates the geologic features and surface as they are today, while the following diagrams are purely hypothetical and represent graphically earlier successive stages in geologic history as interpreted by the author.

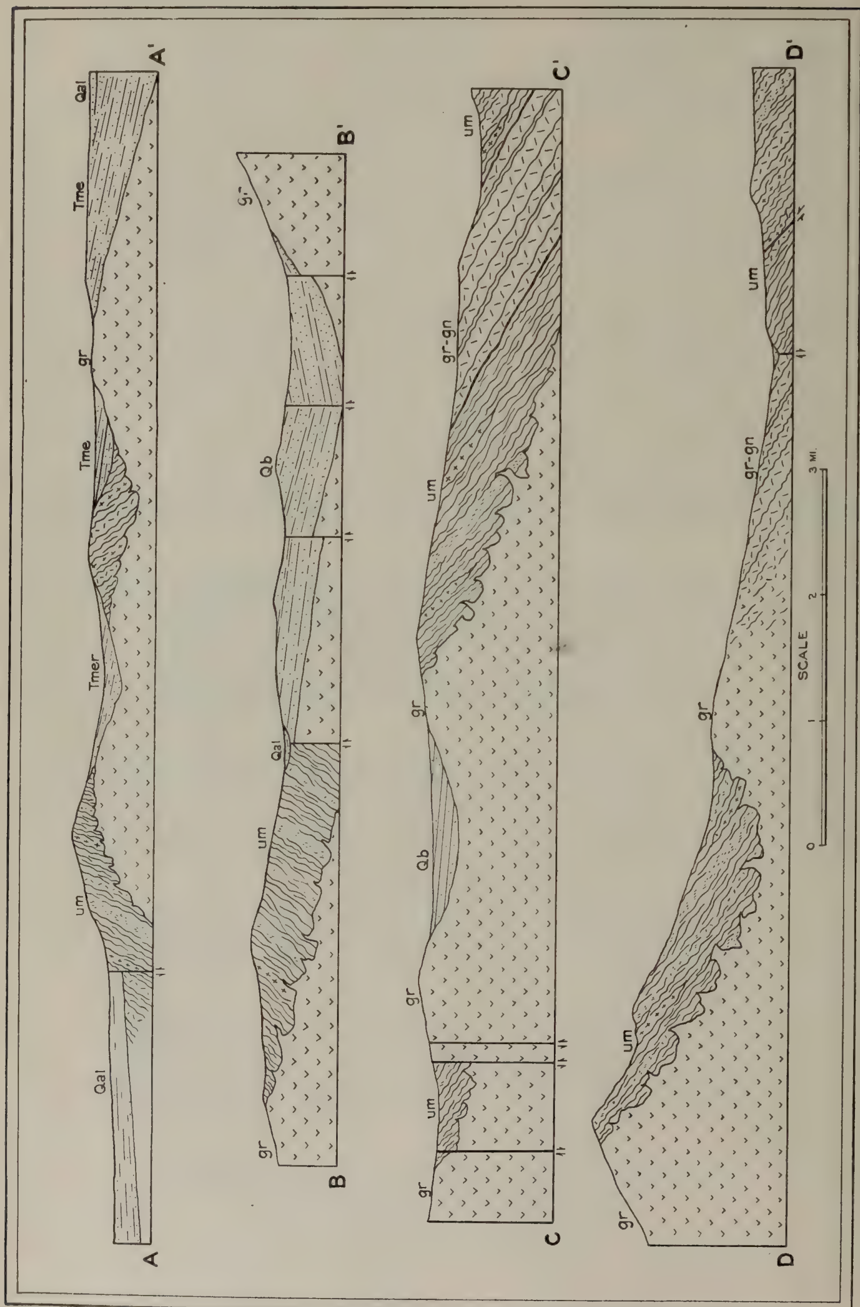
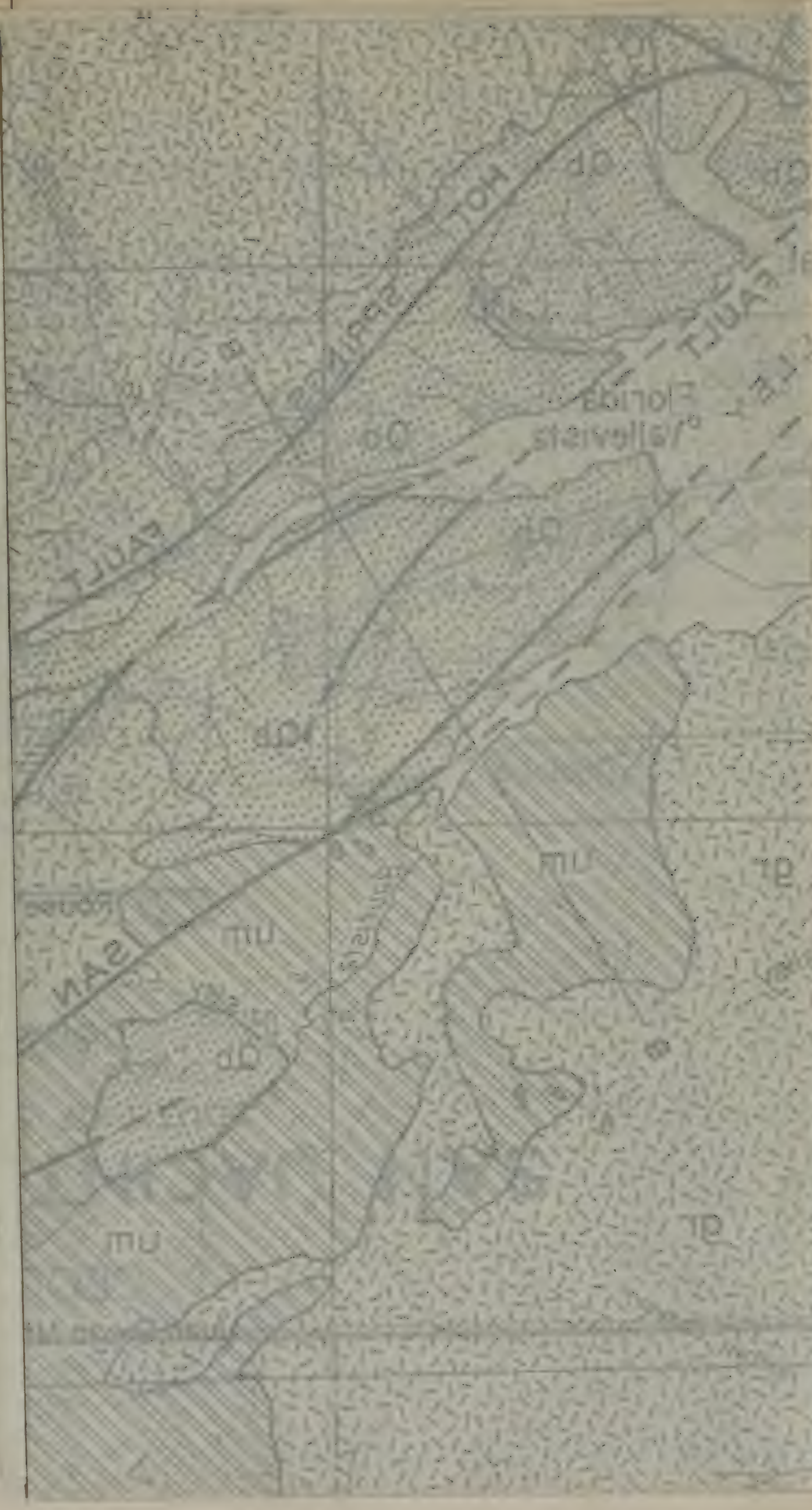


FIG. 23. Structural sections A-A', B-B', C-C', D-D' across geologic map of San Jacinto quadrangle. For explanation of symbols, see geologic map legend.


HOT SPRINGS FAULT
FAULT
Florida
Vallevista
SAN
um
gr

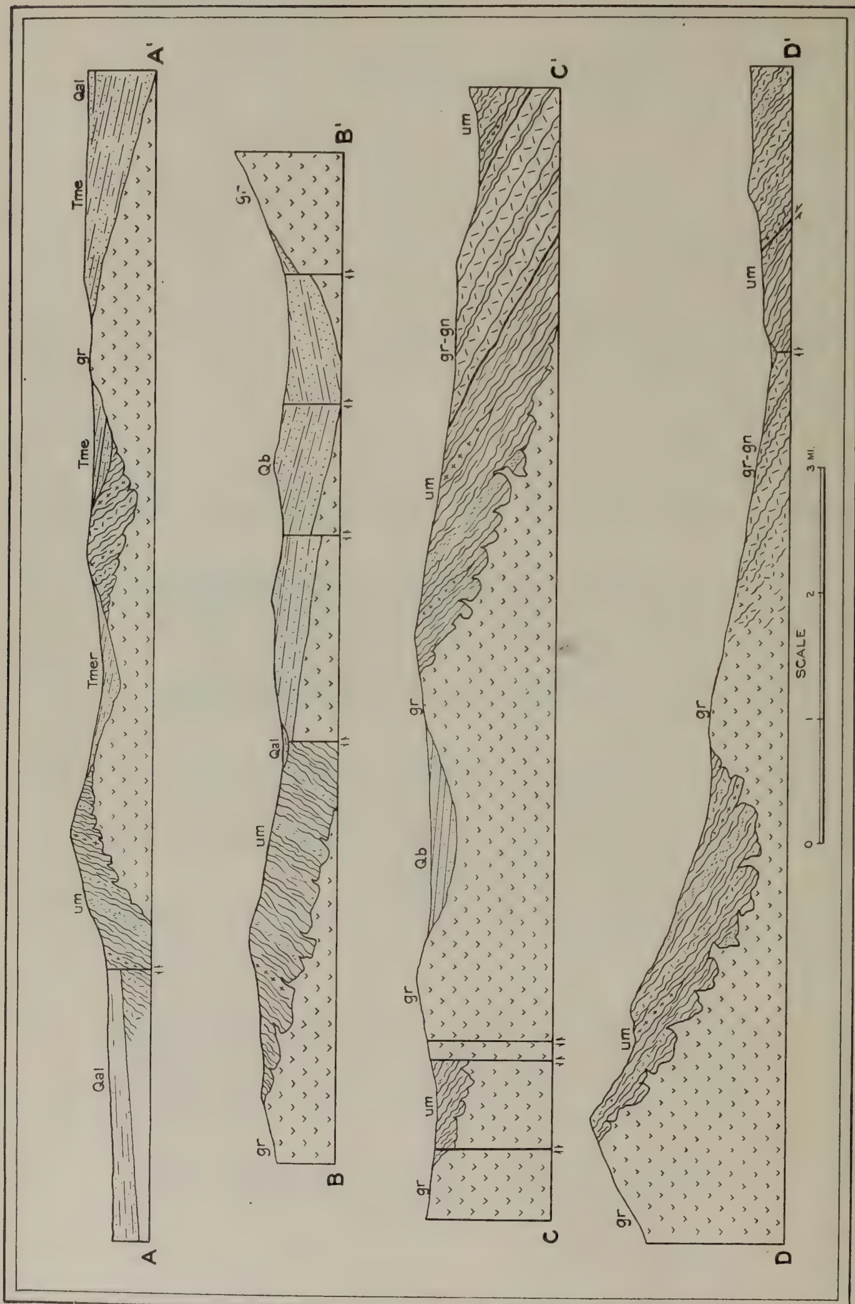


FIG. 23. Structural sections A-A', B-B', C-C', D-D' across geologic map of San Jacinto quadrangle. For explanation of symbols, see geologic map legend.

GEOLOGIC MAP
OF THE
SAN JACINTO QUADRANGLE
SOUTH OF SAN GORGONIO PASS
BY
DONALD M. FRASER
1931

SCALE

SEDIMENTARY ROCKS

Quaternary

Qal — *Alluvium. (Sand and soil of the valley floors and stream debris)*

Qb — *Bautista beds. (Coarse loosely consolidated lenticular grayish sandstone and poorly lithified shale.)*

Tertiary Pliocene

Tme — *Mt. Eden formation. (Non-marine shale and sandstone series forming loosely consolidated strata, tan in color, containing vertebrate fossils.)*

Tmer — *Red Bed member (Mt. Eden formation). (Massive arkosic red beds grading upward into massive gray sandstone and shale.)*

METAMORPHIC ROCKS

Paleozoic or older

um — *Metamorphic series. (Predominantly mica schist, also minor amounts of hornblende schist, limestone and quartzite.)*

IGNEOUS ROCKS

Jurassic ?

gr — *Granite (Typical granite and the most widely distributed rock in the San Jacinto quadrangle.)*

gr-gn — *Granite gneiss (Gneissoid marginal phase of the granite.)*

gb — *Gabbro. (Dense black to greenish black rock with a tendency to gneissoid structure. Post-metamorphic and pre-granitic in age.)*

Faults, exposed.
Faults, buried
Contact
Approximate contact
Gradational contact.

Base map taken from U.S.G.S. San Jacinto quadrangle.

OIL FIELD DEVELOPMENT OPERATIONS

By R. D. Bush, State Oil and Gas Supervisor

From June 28, 1931, to and including October 3, 1931, the following new wells were reported as ready to drill:

Company	Sec.	Twp.	Range	Well No.	Field
FRESNO COUNTY:					
Kettleman North Dome Assoc.	30	21	17	36	Kettleman Hills
KERN COUNTY:					
Signal Oil and Gas Co.	15	26	19	Signal Lincoln 1	Devils Den
C. C. M. O. Co.	23	28	27	38	Kern River
C. C. M. O. Co.	23	28	27	39	Kern River
Thomas H. T. Purman	22	29	21	1	McKittrick
Victor Oil Co.	35	32	23	13	Midway
T. A. Piper	15	27	28	Glide 1	Mt. Poso
Vedder Petroleum Corp., Ltd.	14	27	27	McVan 2	Mt. Poso
A. S. Mayes	3	28	28	1	Round Mountain
Casamera Oil Co.	29	28	20	1-A	
Graham-Loftus Oil Corp.	20	27	22	Carmel 1	
L. C. Osborn	15	30	29	Duff 2	
KINGS COUNTY:					
Howard L. Bryan	4	22	18	1	Kettleman Hills
Kettleman North Dome Assoc.	2	22	17	52	Kettleman Hills
Kettleman North Dome Assoc.	2	22	17	81	Kettleman Hills
Kettleman North Dome Assoc.	34	22	18	76	Kettleman Hills
Eagle Oil & Gas Co., Ltd.	15	23	20	1	
Franz A. Gansneder	2	22	18	Tomer 1	
Valley Exploration Co., Ltd.	12	23	19	Veco 7-12	
LOS ANGELES COUNTY:					
Shell Oil Co.	33	3	13	Reyes 40	Dominguez
Union Oil Co.	33	3	13	Callender 26	Dominguez
Union Oil Co.	33	3	13	Callender 27	Dominguez
Union Oil Co.	33	3	13	Hellman 16	Dominguez
Standard Oil Co.	17	2	14	L. A. Investment 1-67	Inglewood
Beach Petroleum Corp., Ltd.	19	4	12	Harlow 1	Long Beach
The Hancock Oil Co.	19	4	12	Bernstein 1	Long Beach
E. J. Preston Petroleum, Ltd.	13	4	13	33	Long Beach
West American Oil Co.	20	4	12	6	Long Beach
The Cooperative Dev. Co., Ltd.	26	2	15	Community 1	Playa del Rey
Sam B. Herndon Oil Co., Ltd.	28	2	15	4	Playa del Rey
International Petroleum Corp., Ltd.	28	2	15	4	Playa del Rey
The Ohio Oil Co.	28	2	15	Recreation Gun Club 11	Playa del Rey
Wilshire Annex Oil Co.	34	2	14	2	Potrero
Zack J. Farmer	6	4	14	1	Torrance
Zack J. Farmer	6	4	14	2	Torrance
Westwood Oil Producers Co., Ltd.	6	4	14	2	Torrance
William L. Jones	31	2	12	Graham 1	
Ranger Petroleum Corp.	21	4	13	Watson 2	
Simi Oil Co., Ltd.	18	1	17	1	
MERCED COUNTY:					
San Joaquin Exploration, Ltd.	36	10	9	1	
ORANGE COUNTY:					
Paul Edward Patten	35	5	11	1	Huntington Beach
Nuoil Co.	29	6	10	2	Newport
Nuoil Co.	29	6	10	3	Newport
Superior Oil Co.	27	6	10	Irvine 1	Newport
The Pullen Brothers Co.	19	5	11	1	
SAN DIEGO COUNTY:					
Oklahoma Oil Corp.	25	11	8	1	

OIL FIELD DEVELOPMENT OPERATIONS—Continued

Company	Sec.	Twp.	Range	Well No.	Field
SAN MATEO COUNTY:					
J. C. Pavicich	13	5	5	Full Moon 1	
J. C. Pavicich	13	5	5	Full Moon 2	
J. C. Pavicich	13	5	5	Full Moon 3	
J. C. Pavicich	13	5	5	Full Moon 4	
J. C. Pavicich	13	5	5	Full Moon 5	
J. C. Pavicich	13	5	5	Full Moon 5-A	
J. C. Pavicich	13	5	5	Full Moon 6	
J. C. Pavicich	13	5	5	Full Moon 7	
J. C. Pavicich	13	5	5	Full Moon 8	
J. C. Pavicich	13	5	5	Full Moon 9	
J. C. Pavicich	13	5	5	Full Moon 10	
J. C. Pavicich	12	5	5	Full Moon 11	
J. C. Pavicich	12	5	5	Full Moon 12	
SANTA BARBARA COUNTY:					
Bankline Oil Co.	15	4	29	89-5	Elwood
Barnsdall Oil Co.	15	4	29	Luton-Bell 19	Elwood
Barnsdall Oil Co.	15	4	29	Luton-Bell 20	Elwood
James P. Carroll	29	4	27	1	Mesa
The Ohio Oil Co.	16	4	28	1	
TEHAMA COUNTY:					
Crockett Drilling Syn., Inc.	20	24	5	3	
TULARE COUNTY:					
W. A. Campbell	22	22	27	2	
C. E. Pettingall	22	22	27	Dunigan 1	
VENTURA COUNTY:					
H. H. Bell	22	3	21	1	South Mountain
Associated Oil Co.	26	3	23	Lloyd 108	Ventura
Bolsa Chica Oil Corp.	22	3	23	Louis Hartman 6	Ventura

SPECIAL ARTICLES

Detailed technical reports on special subjects, the result of research work or extended field investigations, will continue to be issued as separate bulletins by the Bureau, as has been the custom in the past.

Shorter and less elaborate technical papers and articles by members of the staff and others are published in each number of MINING IN CALIFORNIA.

These special articles cover a wide range of subjects both of historical and current interest; descriptions of new processes, or metallurgical and industrial plants, new mineral occurrences, and interesting geological formations, as well as articles intended to supply practical and timely information on the problems of the prospector and miner, such as the text of the new laws and official regulations and notices affecting the mineral industry.

NOTES ON MINING ACTIVITY IN INYO AND MONO COUNTIES IN JULY, 1931

By W. B. TUCKER, District Mining Engineer

On July 8 and 9 the *Wilshire Bishop Creek Mine* was visited. It is situated on Bishop Creek, 26 miles southwest of Bishop, on the eastern slope of the Sierra Nevada Mountains, at an elevation of 8500 feet.

This property, which was formerly operated by Mr. Gaylord Wilshire, of Los Angeles, and later taken over by one of the banks in Inyo County under receivership, is now under lease and bond to the *Consolidated Metals Corporation,* 752 Mills Building, San Francisco; H. W. Klipstein, Jr., president. This company, during the past year, has done considerable development work on the property.

Their principal work is confined to the Stanford tunnel, which has been driven 400 feet northwesterly on the orebody, with crosscuts directed at regular intervals.

The orebody developed is 8 to 10 feet wide and several hundred feet in length, values varying from $4 to $12 per ton in gold. It is reported that 45,000 tons of ore has been developed above this tunnel with an average value of $8 per ton.

At the time of visit the property was not operating, but the superintendent stated that they expected to resume about the first of September.

In the vicinity of Lone Pine a number of smaller operators were reopening several old properties and also there was some activity in the Beveridge District, as it is reported that the *Keynote Mine* will be reopened by Los Angeles interests; also Mr. Sam Spear is doing some development work on his property in the same district.

In Mono County, on July 28 and 29, the Bodie Mining District was visited. Here the *Treadwell-Yukon Company* for the past two years has been doing development work on the Noonday and Red Cloud mines. They have completed 18,000 feet of drifting and crosscutting

on these properties, but so far have not developed any large commercial orebodies, although they have found some small ore shoots of high-grade gold quartz. The development work is being conducted through the Red Cloud shaft and is confined to the 700 and 800-foot levels.

Within the last year, they have acquired all the adjoining properties in the district and now have a lease and bond on the *Standard Consolidated Mining Company's* holdings. On this property, it is estimated by company engineers that the Standard Hill contains 1,500,000 tons of ore in dumps; also a block of surface ground that will average $1.80 per ton in gold. This dump material is handled by steam shovel and delivered to a 400-ton flotation plant via two 10-ton trucks. The material from trucks is dumped over a 12-inch grizzly; through-size going to 500-ton storage bin, the over-size being rejected by means of a belt conveyor. From ore bin ore is conveyed by belt conveyor to a revolving screen, where it is screened to 1½ inch. Plus 1½-inch material goes to waste dump. This material is reported to assay 40 cents per ton in gold. The minus 1½ inch and finer is conveyed to a 4-foot Symonds cone crusher, where it is reduced to ⅞ inch and finer. This material goes to 200-ton ore bins. From fine-ore bin material is conveyed to 8-foot Hardinge ball-mill in closed circuit with Dorr simplex classifier. Overflow feed from classifier passes two shanking amalgamators. The pulp from amalgamators goes to sump and is then pumped up by Dorr centrifugal pumps to pulp storage tank, where flotation reagents are added, and then flows to three parallel McIntosh roughers. Concentrates from roughers are recleaned by McIntosh and Kraut cleaner cells. Concentrates from cleaner cells go to settling tanks; water is drained off and concentrates dried on hot plates for shipment.

Ball-mill heads carry from $2 to $4 per ton. Tailings assay $1.50 per ton. Total operating cost is 70 cents per ton. The concentrates produced carry from $800 to $1,000 per ton in gold and silver.

The company is at present installing a cyanide plant for the treatment of concentrates.

They are operating the 10-stamp Standard mill on ore that comes from the Noonday and Red Cloud properties and also on ore from other prospects on the different claims in the district. Mr. Duncan, the superintendent, informed me that they have not entirely worked out the metallurgy for the treatment of dump material and that the plant is more or less an experimental plant to determine the results that they could obtain from flotation and might be changed at any time or the capacity increased.

After leaving Bodie the Red Travertine Deposit near Bridgeport was visited to determine what work had been done on this deposit since the last report on Mono County.

Since that time there has been three quarries opened up on the deposit, equipped with derricks and there have been installed a compressor plant, drills, cars and track.

Very little work has been done on the Red Travertine Quarry, but it appears that most of the work has been confined to two quarries on the west side of the deposit, taking out blocks of white travertine, the size of these bocks as shown by quarry operations being 4 feet wide, 4 feet thick and 8 feet long.

The property was idle when visited.

Two days were spent on the *Virginia* and *Dog Creek* placers. The Virginia Creek placers comprise 800 acres of placer claims on Virginia Creek. Claims are owned by A. J. Warrington, of Bridgeport, California. During 1930 these claims were under option to Quincy Stevens and associates, of Los Angeles, who installed a Link Belt shovel with dragline; $1\frac{1}{4}$-yard bucket; also washing and screening plant having a capacity of 500 yards.

Stevens and associates operated the property from July, 1929, to July, 1931. Only a small production was made and they suspended operations due to lack of funds.

The gravel along Virginia Creek can be followed for a distance of 18,000 feet and varies in thickness from 6 to 10 feet; average width 150 to 200 feet. My observations from pannings made from the different cuts are that the pay gravel is from 2 to 4 feet above bedrock, with 6 to 8 feet of secondary gravel which is practically barren. Pannings showed from 10 to 16 colors to the pan, with some good-sized pieces. They report gravel from test runs carrying from 25 cents to $5 per cubic yard. My observations are that 2 to 4 feet of gravel above bedrock will run around 50 cents a yard.

On Dog Creek, the *Dog Creek Placer Mining Company* controls 14 claims in Secs. 34 and 35, T. 4 N., R. 25 E., extending from the junction of Dog Creek and Virginia Creek north on Dog Creek. W. B. Lenhart and C. W. Stone, post-office address Bridgeport, are the men principally interested in this proposition. These parties have installed a dragline scraper and washing plant and expect to be under operation about the first of September.

The gravel is from 6 to 10 feet in thickness and will have the same approximate value as the gravels on Virginia Creek. There is considerable gravel on these two creeks. They have not been worked by early-day operators, and if thoroughly sampled and checked might offer possibilities for considerable production of placer gold.

On July 31 I visited the *Yellow Jacket Canyon Pumice Deposit* located near Benton. Joe Smith, of Laws, owns eight 160-acre locations on these deposits. These properties have been under lease to the *Sierra Minerals Corporation*; K. G. Pulliam, president, Architects Building, Los Angeles.

The company installed a drier and screening plant on the property but before completion of the plant, got into financial difficulties.

There is an extensive deposit of white pumice on these claims similar to the pumice mined by the California Quarries Company.

Mr. Joe Smith, of Laws, informed me that the *Gunter Canyon Barite Deposit* is now owned by the *Crucible Mining Company*, of Ventura, California. Holdings comprise 4 claims. The principal parties interested in this company are Otto Sattler and Myers Bros., of Ventura, California, and Roy E. Nuby, Los Angeles.

Considerable development work has been done on the deposit, consisting of a 240-foot shaft and tunnels.

The property was purchased from Smith October 14, 1929, and operated off and on until April, 1931. He stated they shipped about 62,000 tons of barite, with a gravity of 4.25 and in places on the property had developed a width of 10 to 20 feet of clear, white material.

The *Mammoth Consolidated Mining Company* is installing a mill on their property near Mammoth, Mono County.

ADMINISTRATIVE

WALTER W. BRADLEY, State Mineralogist

Personnel.

There have been no changes nor additions of personnel to be noted during the past three months.

New Publications.

Mining in California (quarterly), April, 1931, being Chapter 2 of the State Mineralogist's Report XXVII. Price 25 cents. Contains: 'The Mountain Copper Company, Ltd., Cyanide Treatment of Gossan;' and the following reports under the Geologic Branch: 'Stratigraphic Significance of the Kreyenhagen Shale,' 'Diatoms and Silico-flagellates,' 'Foraminifera of the Kreyenhagen Shale,' 'Preliminary Report of the Geology of Santa Cruz Island.'

Commercial Mineral Notes, Nos. 100, 101, 102, July, August and September, 1931, respectively.

Mails and Files.

The Division of Mines maintains, in addition to its correspondence files and the library, a mine file which includes original reports on the various mines and mineral properties of all kinds in California.

During each quarterly period there are several thousand letters received and answered at the San Francisco office alone, covering almost every phase of prospecting, mining and developing mineral deposits, reduction problems, marketing of refined products and mining law. In addition to this, hundreds of oral questions are answered daily, both at the main office and the district offices, for the many inquirers who come in for personal interviews and to consult the files and library.

MINERALS AND STATISTICS

Statistics, Museum, Laboratory

HENRY H. SYMONS, Statistician and Curator

STATISTICS

California counties produced commercially fifty-one different mineral substances during 1930, having a total value of $365,604,695 (see July issue MINING IN CALIFORNIA). The complete annual report on the mineral production for 1930 is now in press as Bulletin No. 105 of the State Division of Mines.

Gold was the first, and for many years, the most important single mineral product of California. Although now surpassed for a number of years in annual value by petroleum, by cement beginning with 1920, by natural gas and miscellaneous stone in 1923, it still heads our metal list, and California continues to outrank all the other gold producing states of the United States, including Alaska. In fact, at present, California is producing approximately 20% of the gold mined in the entire United States.

The gold yield has decreased in recent years, not only in California but in the country as a whole. Meanwhile, the actual gold reserves (monetary stock on hand) of the United States has increased to such an extent that we now hold practically one-half of the world's stock.

There has been a renewal in the development of both lode and placer gold properties in California during the last two years. This is shown in the number of mines worked. There were 480 lode properties and 892 placers operating in 1930, as compared with 324 lode and 478 placers in 1929.

The production of gold in California during 1930 totaled 457,199.98 fine ounces worth $9,451,162, being an increase of 44,720.73 fine ounces over the 1929 yield. The deep or lode mines output accounted for 5,696,019 and the placers (mainly the dredges) produced $3,755,143.

As the Division of Mines has never independently gathered the statistics of gold and silver production, these figures, as in former years, are published by cooperation with and through the courtesy of Mr. V. C. Heikes of the Division of Minerals and Statistics, U. S. Bureau of Mines.

The largest gold production for 1930 is reported from Nevada County, with an output of 106,109.87 fine ounces ($2,193,486); Amador County second with 89,019.24 fine ounces ($1,840,191); Sacramento County third with 83,432.95 fine ounces ($1,724,712); followed in turn by Yuba, Sierra, Plumas, Trinity, Shasta. It will be noted that the four leading counties held the same order that they did in 1929; with Nevada holding first place as a gold-producing county with an output exceeding that of Yuba or Amador, which held first and second places, respectively, in 1928, with Sacramento fourth that year. The gold from Yuba and Sacramento comes almost entirely from dredges, while that from Nevada and Amador counties comes mainly from the lode mines.

Distribution of the 1930 gold output by counties was as follows:

County	*Number of producers* *Lode*	*Placer*	*Value*
Amador	23	9	$1,840,191
Butte	11	78	126,858
Calaveras	30	27	112,913
Contra Costa	1	--	102,036
Del Norte	--	2	279
El Dorado	35	28	78,019
Fresno	2	2	5,916
Humboldt	4	7	2,255
Imperial	--	1	148
Inyo	22	1	20,466
Kern	35	4	165,435
Lassen	4	--	2,946
Madera	4	3	1,062
Mariposa	24	27	58,985
Merced	--	1	88,328
Mono	7	--	26,234
Napa	1	--	36,532
Nevada	65	83	2,193,466
Placer	4	97	29,338
Plumas	13	103	405,359
Riverside	8	--	4,833
Sacramento	2	14	1,724,712
San Bernardino	48	8	59,442
San Diego	6	--	2,234
San Luis Obispo	--	1	1,461
Shasta	24	69	226,214
Sierra	17	46	589,249
Siskiyou	21	107	70,332
Trinity	13	88	330,003
Tulare	2	--	36
Tuolumne	49	16	67,691
Ventura	1	--	221
Yuba	3	66	968,614
Totals	480	892	$9,451,162

The value of the total gold produced in California from 1848 to 1930, inclusive, is $1,841,656,194. There was no segregation of the State's output by counties until 1880. From 1880 to 1930, inclusive, Nevada led all the counties in total of production, followed by Amador. It will be noted that these counties held the same relative rank in gold output during this period as they did in 1930.

The 16 leading counties in gold output 1880 to 1930, inclusive, are:

County	*Value*
Nevada	$130,209,706
Amador	105,727,712
Yuba	73,741,113
Calaveras	56,134,340
Sacramento	45,676,812
Tuolumne	38,499,358
Sierra	37,807,209
Placer	33,169,575
Trinity	32,403,901
Shasta	32,053,369
Butte	30,715,095
Mono	23,025,769
Kern	22,666,686
Plumas	20,917,916
El Dorado	14,957,774
Mariposa	13,236,040

The following is quoted from the advanced statement of gold in 1929 by courtesy of the U. S. Bureau of Mines,[a] Department of Commerce:

"The total recoverable gold in ore and gravels treated in California in 1930, according to Victor C. Heikes of the U. S. Bureau of Mines, was valued at $9,451,162, of which 481 lode operations yielded $5,696,019 and 892 placer operations (including dredges) $3,755,143. Compared with the gold yield in 1929 this was an increase of $924,459, with the lode mines showing an increase of $1,039,923 and the placer mines a decrease of $115,464. Of the total gold yield in 1930 lode operations yielded 60 per cent and placer operations 40 per cent. Only 3 counties had a production of gold exceeding $1,000,000 and these were, in order of rank, Nevada, Amador, and Sacramento; Yuba, Sierra and Plumas following next in order of rank. Of the lode gold output gold ore and tailings yielded 90 per cent, copper ore, etc., 7 per cent, and silver ore 1 per cent. Of the placer gold output dreges yielded 92 per cent, surface placers 4 per cent, drift placers 2 per cent, and hydraulic placers 2 per cent. The gold output of 24 dredges (25 in 1929, including a small experimental dredge) was 4 per cent less than in the preceding year. Twenty-eight companies in the State produced more than 1000 ounces of gold each and contributed 90 per cent of the total gold output. The largest producers of gold were the Empire Star Mines Co. (Ltd.), Natomas Company, Yuba Consolidated Gold Fields, Kennedy Mining and Milling Co., Argonaut Mining Co., Original Sixteetn to One Mine (Inc.), Central Eureka Mining Co., Capital Dredging Co., Walker Mining Co., and Idaho Maryland Mines Co.

"In Nevada County the Empire Star Mines Co. developed a new vein with encouraging results. At the North Star mines a leasing system was inaugurated and the North Star was equipped with flotation machines for testing oxidized ores and current tailing from the Empire plant. An aerial tram, which carries the North Star ore to the Empire mill, now connects the two properties. The Pennsylvania tram line handles waste from the Empire mine and also carries ore from the Pennsylvania shaft to the Empire mill. At the Idaho Maryland, development was continued with encouraging results and enlarged milling facilities were planned. Reconditioning of the Brunswick mill on an adjoining property was under way in order to provide for the increase in millilng. The American Foundation Co., operating the Murchie gold mine, increased the capacity of its flotation mill and the gold production was increased. Development of the Hoge, Grass Valley-Nevada City district continued. In Amador County with the Kennedy mine and mill again on an active operating basis and the Argonaut taking on new life from ore developed on the 5500-foot level, the production of gold in the Jackson district will show an increase compared with the 1929 output. The Central Eureka, however, did not come up to its usual production and the Moore mine was inactive. The custom cyanide plant of the Amador Metals & Reduction Co. was operated without interruption on tailing and concentrates. In the Lancha Plana district the dredge operating on the Amador County side of the Mokelumne River had an increased gold yield. Mining of the Iron Mountain gossan deposit in Shasta County by the Mountain Copper Co. was actively carried on and about 8000 tons of gold ore was treated monthly by cyanidation. Capacity of the mill was recently doubled. In Trinity County the Trinity, Lewiston, and Madrona dredges were in operation, but in Shasta County the dredge on Clear Creek was dismantled. The Yuba Consolidated Co. operated 4 boats in the Hammonton field, the Capital Dredging Co., 3 boats in the Folsom field, the Natoma Co. 6 boats in the Natoma field, and the Hammon Engineering Co. was operating the 2 boats of the La Grange Gold Dredging Co. in Merced and Stanislaus counties. Exploration work was continued in the Bodie field, Mono County, by the Treadwell Yukon Co., with especial activity centered on the Noonday vein of the Red Cloud property."

[a] U. S. Bureau of Mines, Dept. of Commerce advance statement for 1930 and Press Bull. Jan. 2, 1931.

MUSEUM

The museum of the State Division of Mines possesses an exceptionally fine collection of rocks and minerals of both economic and academic value. It ranks among the first five of such collections in North America; and contains not only specimens of most of the known minerals found in California, but much valuable and interesting material from other states and foreign countries as well.

Mineral specimens suitable for exhibit purposes are solicited, and their donation will be appreciated by the State Division of Mines as well as by those who utilize the facilities of the collection.

The exhibit is daily visited by engineers, students, business men, and prospectors, as well as tourists and mere sightseers. Besides its practical use in the economic development of California's mineral resources, the collection is a most valuable educational asset to the State and to San Francisco.

LABORATORY

Frank Sanborn, Mineral Technologist

The laboratory of the Division of Mines is maintained for the purpose of identifying minerals and making qualitative analyses of rocks. These determinations and analyses are made without cost to those who seek the services of this state department. Ordinarily, a small sample weighing not over half a pound, in the lump form if possible, should be submitted with a letter stating what particular tests are desired, if there is a special reason for sending the material. Not more than three samples should be sent at one time, nor is it necessary to send more than one.

When requested, assistance in finding a market for a mineral will be given. When such help is desired, a small representative sample of the material for which a market is sought should accompany the request.

Several thousand mineral determinations are made annually by the Division of Mines, and prospecting and exploitation of the State's mineral wealth increases as the State becomes more thickly populated.

LIBRARY

HERBERT A. FRANKE, Librarian

In addition to the numerous standard works, authoritative information on many phases of the mining and mineral industry is constantly being issued in the form of reports and bulletins by various government agencies.

The library of the Division of Mines contains some five thousand selected volumes on mines, mining and allied subjects, and it is also a repository for reports and bulletins of the technical departments of federal and State governments and of educational institutions, both domestic and foreign.

It is not the dearth of the latter publications, but rather a lack of knowledge of just what has been published and where the reports may be consulted or obtained, that embarrasses the ordinary person seeking specific information.

To assist in making the public acquainted with this valuable source of current technical information, MINING IN CALIFORNIA contains under this heading a list of all books and official reports and bulletins received, with names of publishers or issuing departments.

Files of all the leading technical journals will be found in the library, and county and State maps, topographical sheets and geological folios. Current copies of local newspapers published in the mining centers of the State are available for reference.

The library and reading room are open to the public during the usual office hours, when the librarian may be freely called upon for all necessary assistance.

OFFICIAL PUBLICATIONS RECEIVED

Governmental.

U. S. Geological Survey:

Bulletins:

818. Geology and Mineral Resources of the Cleveland District, Ohio.
819. The Wasatch Plateau Coal Field, Utah.

Professional Papers:

162. Geology and Ore Deposits of the Goodsprings Quadrangle, Nevada.
163. The Significance of Geologic Conditions in Naval Petroleum Reserve No. 3, Wyoming.

165-C. Geology of the Eastern Part of the Santa Monica Mountains, Los Angeles County, California.

Water-Supply Papers:

637-D. Geology and Water Resources of the Middle Deschutes River Basin, Oregon.

638-A. A Preliminary Report on the Artesian Water Supply of Memphis, Tennessee.

642. Part II, South Atlantic Slope and Eastern Gulf of Mexico Basins.
651. Part XI, Pacific Slope Basins in California.
652. Part XII, North Pacific Slope Drainage Basins in Washington.

653. Part XII-B, Snake River Basin.
654. Part XII, Pacific Slope Basins in Oregon.
661. Part I, North Atlantic Drainage Basins.
664. Part IV, St. Lawrence River Basin.
665. Part V, Hudson Bay and Upper Mississippi River Basins.
666. Part VI, Missouri River Basin.
667. Part VII, Lower Mississippi River Basin.
668. Part VIII, Western Gulf of Mexico Basins.
669. Part IX, Colorado River Basin.
670. Part X, The Great Basin.
Part XI, Pacific Slope Basins in California.
672. Part XII, North Pacific Slope Drainage Basins. A. Pacific Slope Basins in Washington and Upper Columbia River Basin.
673. Part XII, North Pacific Slope Drainage Basins. B. Snake River
674. Part XII, North Pacific Slope Drainage Basins. C. Pacific Slope Basins in Oregon and Lower Columbia River Basin.
691. Part XI, Pacific Slope Basins in California.

U. S. Bureau of Mines:

Bulletins:

336. Agglutinating, Coking, and By-Product Tests of Coals from Pierce County, Washington.
338. Quarry Accidents in the United States, 1929.
341. Coal Mine Fatalities in the United States, 1929.
342. Metal Mine Accidents in the United States, 1929.

Technical Papers:

500. Relationship between Volatility and Consumption of Lubricating Oils in Internal-Combustion Engines. By G. Wade and A. L. Foster.
501. Results of Electrical Resistivity and Electrical Induction Measurements, at Abana Mine, Quebec, Canada, by E. V. Polter.
503. Accidents at Metallurgical Works in the United States, 1929. By W. W. Adams.

Mineral Resources of the United States:

Gold, Silver, Copper, Lead and Zinc in Utah in 1929. By C. N. Gerry.
Carbon Black in 1930. By G. R. Hopkins and H. Backus.
Fuel Briquets in 1930. By W. H. Young and J. M. Corse.
Petroleum in 1929. By G. R. Hopkins and A. B. Coons.
Fluorspar and Cryolite in 1930. By Hubert W. Davies.
Asphalt and Related Bitumens in 1929. By A. H. Redfield.
Gold, Silver. Copper, Lead and Zinc in Nevada in 1929. Mine report. By V. C. Heikes.
Natural Gasoline in 1929. By O. R. Hopkins and E. M. Seeley.
Cement in 1929. By B. W. Bagley.
Zinc in 1929 (General Report). By Elmer W. Peterson. Gold, Silver, Copper, Lead and Zinc in New Mexico and Texas in 1929. Mine Report by Chas. W. Henderson.
Potash in 1930. By A. T. Coons.
Gold, Silver, Copper, Lead and Zinc in Montana in 1929. Mine Report by C. N. Gerry and T. H. Miller.
Gold, Silver, Copper. Lead and Zinc in Arizona in 1929. Mine Report by C. N. Gerry and T. H. Miller.
Antimony in 1930. By Paul M. Tyles.
Fuller's Earth in 1930. By Jefferson Middleton.
Salt, Bromine, and Calcium Chloride in 1930. By A. T. Coons.

Report of Investigations:

3097. The Acidity of Bennett Branch of Sinnemahoning Creek, Pennsylvania, During Low Water, 1930. By R. D. Leitch.
3101. Retreatment of Sayreton Jig Middlings on Coal Washing Tables. By A. C. Richardson and W. B. Gandrud.
3102. The Acidity of Black Lick and Yellow Creeks, Pennsylvania, During Low Water in 1930. By R. D. Leitch.
3104. The Overheating of Rubber Sheathed Trailing Cables. By L. C. Ilsley and A. B. Hooker.

3105. Flotation of Low Grade Phosphate Ores. By H. M. Lawrence and E. Roca.
3106. Leaching Oxidized Copper Ores. Effect of Strength of Acid in Leaching Solvent. By John D. Sullivan and G. L. Oldright.
3110. A Study of Falls of Roof and Coal in Mines of Harrison County, West Virginia. By J. W. Paul and J. N. Geyser.
3111. The Effect of Certain Operating Variables on the Efficiency of the Coal Washing Table. By H. F. Yancy and C. G. Black.
3112. Flotation Reagents, 1929. By L. T. Miller and R. L. Kidd.
3113. Roof Support in Coal Mines in The Irwin, Greensburg and Latrobe Basins, Westmoreland County, Pennsylvania.
3116. A Study of the Properties of Texas, New Mexico Polyhalite Pertaining to the Extraction of Potash. (Suggested processes for the production of Syngenite and by-product Magnesia.) By H. H. Stooch and N. Fragen.
3117. Cooperative Research Between the U. S. Bureau of Mines and the Safety in Mines Research Board. By R. V. Wheeler and G. S. Rice.
3119. The Acidity of Several Pennsylvania Streams During Low Water. By R. D. Leitch.
3120. Determination of Magnetite in Copper Clays. By Lathrop E. Roberts and R. L. Nugent.
3121. Comparison of Storage-Battery and Cable. Reel Gathering Locomotives in a West Viriginia Coal Mine. By C. W. Owings.
3122. Test on Brick Kilns Fired With a Stoker. By W. E. Rice and R. R. Falles.
3127. A Novel Method of Ventilating a Pennsylvania Coal Mine. By C. W. Owens.
3128. Hydrogen Sulphide Contents of the Gas in Some Producing Oil Fields. By John M. Devine and C. J. Wilhelm.
3129. Twenty-third Semi-annual Motor Gasoline Survey. Part I. By E. C. Lane, E. L. Gaston and A. J. Kraemer.
3130. Properties of Typical Crude Oil From the East Texas Field. By E. L. Ganton.
3132. Experiments to Determine the Minimum Amount of Coal Dust Required for Propagation of a Mine Explosion. By G. S. Rice and H. P. Greenwald.
3133. Sand Gravel Safety Contest of 1930. By W. W. Adams.
3134. Active List of Permissible Explosives and Blasting Devices Approved Prior to June 30, 1931.
3137. Consumption of Explosives in May, 1931. By W. W. Adams and L. S. Gerry.
3138. Reduction of Evaporation Losses from Gasoline Bulk Storage Station Tanks. By Ludwig Schmidt and C. J. Wilhelm.
3140. Official Changes in the Active List of Permissible Explosives and Blasting Devices for August, 1931.
3141. Coal Mine Fatalities in June, 1931. By W. W. Adams and L. Chenoweth.
3142. Twenty-third Semi-annual Motor Gasoline Survey. Part II. Specification date. By E. C. Lane.
3144. Consumption of Explosives in June, 1931. By W. W. Adams and L. S. Gerry.

Information Circulars:

6458. Mining Laws of Cuba. By I. Aitkens.
6459. Emeralds. By Irene Aitkens.
6464. Mining Methods and Costs of Mining Copper Ore at the Verde Central Mines, Inc., Jerome, Arizona. By Robert H. Dickson.
6465. Zircon. By E. P. Youngman.
6466. Bismuth. By Paul M. Tyler.
6467. Milling Methods and Costs at the Concentrator of the Old Dominion Co., Globe, Arizona. By D. Le Forrester and W. B. Cramer.
6468. Iceland Spar and Optical Fluorite. By H. Herbert Hughes.
6469. Progress in Metal Mine Ventilation in 1930. By D. Harrington.
6470. Mining Methods and Costs at the Porcupine United Gold Mines, Rochester Mine, at Timmino, Ontario. By J. D. Tolman.

6471. Rubies and Sapphires. By I. Aitkens.
6472. Quartz and Silica, Part I. General Summary. By R. M. Santmyers, August, 1931.
6473. Quartz and Silica, Part II. Quartz, Quartzite and Sandstone. By R. M. Santmyers.
6474. Quartz and Silica, Part III. Sand and Miscellaneous Silicas. By R. M. Santmyers.
6475. Rhenium (and Masurium). By Paul M. Tyler.
6476. Milling Methods and Costs at the Argonaut Mill, Jackson, California. By Selim E. Woodworth.
6477. Mining Laws of the Netherlands. By E. P. Youngman.
6479. Milling Methods and Costs at The Arthur and Magna Concentrators of the Utah Copper Co. By H. S. Martin.
6480. Tunnel Driving Methods Used at the Ojuela Unit of the Componia Minera de Penoles. S. A. Ojuela, Durango, Mexico. By John P. Savage.
6481. Organization Plan of the Holmes Safety Association. By J. J. Forkes and M. J. Ankeny.
6482. Chalk, Whiting and Whiting Substitutes. By Oliver Bowles.
6484. State Mine Inspectors. Their Qualifications, Appointment and Remuneration. By J. A. Huff and V. V. Baker.
6489. Milling Methods and Costs at the Verde Central Concentrator, Jerome, Arizona. By R. H. Dickens and E. M. Smith.
6490. Mining Methods of Kirkland Lake Gold Mining Co. (Ltd.) at Kirkland Lake, Ontario. By J. C. Dumbritle.
6491. Turquoise. By I. Aitkens.
6492. Milling Methods at the Midvale Concentrator of the U. S. Smelting, Refining and Mining Co., Midvale, Utah. By R. A. Pallanch.
6493. Opals. By I. Aitkens.
6494. List of Permissible Self-contained Oxygen Breathing Apparatus, Gas Masks and Hose Masks.
6495. Underground Chute Gates in Metal Mines. By Chas. F. Jackson and John B. Knaebel.
6497. Milling Methods and Costs at the Montana Mine Concentrator of the Eagle Picker Lead Co., Ruby, Arizona. By D. E. Andrews.
6498. Method and Cost of Quarrying Limestone and Shale at the Quarry of the Trinity Portland Cement Co., Dallas, Texas. By J. William Ganser.
6499. Boron and Its Compounds. By R. M. Santmyers.
6501. Essential Factors Influencing Subsidence and Ground Movement. By R. W. Crane.
6502. Topaz. By I. Aitkens.
6504. Umber, Sienna and Other Brown Earth Pigments. By R. M. Santmyers.
6505. How and Why Fatalities Occurred in Pennsylvania Bituminous Coal Mines During the Five Year Period 1926–1930. By W. J. Lane.
6506. Lost-Time Accidents in Some Alabama Coal and Iron Mines During 1930. By F. E. Cash and H. B. Humphrey.
6507. Safety Inspections in and Around Iron Mines in the Lake Superior District. By F. S. Crawford.
6508. Milling Practice of the Kirkland Lake Gold Mines (Ltd.), Kirkland Lake, Ontario. By John Dixon.
6510. Safety Standards and Safety Suggestions at Iron Mines in the Lake Superior Region. By F. S. Crawford.
6514. Mining Methods of the Molybdenum Corporation of America at Questa, New Mexico. By J. B. Carmon.
6515. Mining Methods and Costs at the Champion Copper Mine, Painesdale, Michigan. By Albert Mendelsohn.
6517. Fatalities in Tennessee Coal Mines. By H. B. Humphrey and F. E. Cash.
6520. Safety Education at Iron Mines of the Lake Superior Region. By F. S. Crawford.
6523. Pyrites. General Information. By Robert H. Ridgway.
6524. Utilization of Dolomite and High Magnesium Limestone. By Paul Hatmaker.

6525. Mining Practice and Costs at the Vipond Mine, Timmons, Ontario, Canada. By Robert C. Dyer.
6528. Geophysical Abstracts No. XXVII. By Frederick W. Lee.
6559. Geophysical Abstracts No. XXIX. By Frederick W. Lee.

California State Division of Water Resources:

Bulletin No. 21-B. Report on Irrigation Districts in California for the year 1930.

Bulletin No. 33. Rainfall Penetration and Consumptive Use of Water in Santa Ana River Valley and Coastal Plain. A Cooperative Progress Report by the Division of Agricultural Engineering of the U. S. Department of Agriculture, 1930.

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Bulletin No. 11. Mining Laws of Colorado with Mine Rules and Regulations Appended.

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Florida State Geological Survey:

Bulletin No. 7. The Pensacola Terrace and Associated Beaches and Bars in Florida. By Frank Leverett. Twenty-first, Twenty-second Annual Report.

Georgia Geological Survey:

Bulletin No. 45. Shales and Brick Clays of Georgia. By Smith.

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Bulletin No. 60. Quarter Centennial Celebration.

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Kentucky Geological Survey:

Series VI, 1931. Structural Geological Map of Kentucky.

Natural Gas in Western Kentucky.

New Mexico Bureau of Mines and Mineral Resources:

Oil and Gas Map of New Mexico. By D. C. Winchester.

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Bulletin No. 35. Geology of Jefferson County.

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A Syllabus of Pennsylvania Geology and Mineral Resources. By George H. Ashley.

Alberta Department of Lands and Mines:

Regulations Respecting Drilling and Production Operations of Oil and Natural Gas Wells. (O. C. 769–31.)

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Mem. No. 166. Geology and Ore Deposits of Rouyn. Harricanou Region, Quebec. By H. C. Cooke, W. F. James and J. B. Mawdsley.

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The Geology of Manchester and the Southeast Lancashire Coalfield.

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No. 26. Institute of Metals: Materials to the Charactistic of the Tommot Gold District.

No. 36. Institute of Geophysis: General Characteristics of the Gravity Method of Prospecting, According to the Field Works Performed by the Former Geological Committee in 1925–1928.

No. 53. Oil Institute: The Okha Oil Region (North Sakhalin).

Bulletin No. 32. Geological Explorations in Davalaghez, Transcaucasia, (preliminary report). By N. Yaconler.

Bulletin No. 36. Phenomena of Submarine Rock Creeps in the Artinskian Beds. By A. A. Ivanor.

Geological Explorations in the Systems of the Rivers Zypi and Muir in Transbaikalea.

Geological Explorations Along the Lower Course of Amu-Donia. Materials to the Geology and Petrography of North Kamtahatka.

Attitude of the Carboniferous Beds in the Don Region.

No. 116. General Methods of Calculation of Ore Reserves. By A. Juransky.

General Geological Map of the European Part of the U. S. S. R. Sheet 108. By George Fredericks.

East Siberian Branch of Geological and Prospecting Survey, U. S. S. R., Siberia, Irkustak:

No. 4. Records of Geology and Mineral Resources of East Siberia.

Fascicle 26. Some Geological Observations in the Region of Sioni Village, by the Urir Lora, and Observations on the Age of the Conglomerates of Elebi Rouge (Georgian S. S. R.) By N. Vassoenich.

Fascicle 27. Quarternary Deposits in the Western Part of Sheet 41. By A. Mondrinor.

Fascicle 29. On the Mysonski Iron Ore Deposit in the Buriat-Mongolian Aut. S. S. R. By P. J. Kasatkin and S. S. Smirnor.

Fascicle 38. Structure of the Eastern Coast of North Sakhalin Between the Leoptu Gull and Leavensternleape. By A. J. Kosygin.

Fascicle 39. The Jurassic Marine Deposits in Eastern Transbarkalia. By J. Khudiaer.

Fascicle 41. Geological Explorations in the Eastern Half of Sheet 45 of the Geological Map of the European Part of the U. S. S. R. Lgor Circuit (preliminary report on the works of 1927–28).

Fascicle 43. Industrial Evaluation of the Veshnegonsk Feldspar Deposit. By A. Amelandor.

Fascicle 44. The Reabinenskaia Raznedka Deposit. By V. Domaner.

Fascicle 48. Geological Explorations in the Southeastern Part of Sheet 26 of the Geological Map of the European Part of U. S. S. R.

Fascicle 64. Geological Explorations in Mingelia (preliminary report on the works executed in 1929). With one map. By B. B. Meffert.

Fascicle 8. Geological Map of the Zeia Gold District. Description of Sheet II. By P. Yunarosky.

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Bulletin No. 13. The Tertiary Mollusca of the Gisborne District. By J. Manwick.

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Economic Geology of the Fife Coalfields, Area 1. Dunfermline and West Fife.

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Marine Algae of the Revillagigedo Islands Expedition in 1925.
Geographic Variation in the Richardson Grouse. By Harry L. Swarth.
XII Pelagic Mammals from the Temblor Formation of the Kern Region, California. By Remington Kellogg.

Societies and Educational Institutions:

California Academy of Sciences:

Fourth Series, XI, Marine Algae of the Revillagigedo Islands Expedition in 1925. By William Albert Setchell and Nathaniel Lyon Gardner.

Canadian Institute of Mining and Metallurgy:

No. 232, August, 1931.
No. 233, September, 1931.

Cleveland Museum of Natural History:

Bulletin No. 51. September, 1931.

Colorado Scientific Society:

Vols. 11 and 12. The Paleontology of the Denner Quadrangle, Colorado. By J. Harlan Johnson.

Economic Geology:

Vol. 26, No. 5.
Vol. 26, No. 6.

Field Museum of Natural History:

Vol. IV. Publication 297. No. 6. Occurrence of the Allegatoroid genus Allognalhosuchus in the Lower Oligocene. By Byron Patterson.

Vol. IV. Publication 298. No. 7. A Silurian Worm and Associated Fauna. By Sharat Kunar Roy and Carey Croneis.
Vol. IV. Publication 299. No. 8. A Fossil Turtle from Peru. By Karl P. Schmidt.

Geological Society of America:

Vol. XLII, No. 2. June, 1931.

Institute of Mining and Metallurgy:

No. 233, August, 1931.
No. 234, September, 1931.
No. 235, October, 1931.

Journal of Geology:

Vol. XXXIX, No. 5.
Vol. XXXIX, No. 6.

Library of Congress:

Vol. XXII, No. 4.
Vol. XXII, No. 5.

Mineralogical Society of America:

Vol. XVI, No. 9.
Vol. XVI, No. 10.

National Research Council:

Report of the Committee on Sedimentation, 1929–1930. By Division of Geology and Geography.

Pennsylvania State College, School of Engineering:

Bulletin No. 12. Proceedings of the Fourth Oil Power Conference Held at the Pennsylvania State College, June 12th to 14th, 1930.

Seismological Society of America:

Vol. XXI, No. 2.
Vol. XXI, No. 3.

University of California, Geological Sciences:

Vol. XIX, 1929–1931. Index.
Vol. XX, No. 10, pp. 361–374, Pleistocene Bisdo from the Carpinteria Asphalt of California. By Loye Miller.
Vol. XXI, No. 1.

University of Minnesota:

Mining Directory of Minnesota, 1931.

University of Nevada:

Vol. XXV. Nos. 3–4, June 1, 1931. No. 3. Notes on Ore Deposits at Cave Valley, Patterson District, Lincoln County, Nevada. By F. C. Schroder.
No. 4. The Preliminary Survey of The Scossa Mining District, Pershing County, Nevada.

Books.

Petroleum in the United States and Possessions. By Ralph Arnold and Wm. J. Kemnitzer.
The Mineral Industry During 1930, Vol. XXXIX. Edited by G. A. Roush.

Maps.

Kentucky:

Geologic Map of Kentucky. By W. R. Jellson.
U. S. Geological Survey Topographic Maps.

Arizona:

Hyder Quadrangle.
Kim Quadrangle, Yuma County.

California:

Goose Lake Quadrangle, Kern County.
Kettleman Plain Quadrangle, Kings County.
Discovery Well Quadrangle, Kings County.
Avenal Gap Quadrangle (Kings and Kern counties).
Conoas Creek Quadrangle (Fresno County).
Middle Dome Quadrangle (Kings County).

Missouri:

Fulton Quadrangle, Callaway County.

North Dakota:

Tokio Quadrangle.
Oberon Quadrangle.
Devils Lake Quadrangle.

Oregon:

Madras Quadrangle.

Texas:

Tordia Quadrangle.
Grapevine Quadrangle.
Tolar Quadrangle, Hood County.
Santo Quadrangle, Palo Pinto County.
Carrollton Quadrangle.
Morgan Quadrangle.
Elm Mott Quadrangle, McLennan County.
Valley Mills Quadrangle, McLennan County.

Washington:

Steamboat Mountain Quadrangle.

Iowa:

Indianola Quadrangle, Warren County.

Current Magazines on File.

For the convenience of persons wishing to consult the technical magazines in the reading room, a list of those on file is appended:

American Petroleum Institute Bulletin, New York City.
Architect and Engineer, San Francisco.
Asbestos, Philadelphia, Pennsylvania.
Asbestology, Canadian Asbestos Co., Montreal, Canada.
Brick and Clay Record, Chicago.
California Safety News, San Francisco.
Canadian Mining Journal, Gardenvale, Quebec.
Caterpillar, San Leandro, California.
Chemical and Metallurgical Engineering, New York City.
Chemical Engineering and Mining Review, Melbourne, Australia.
Commerce Reports, Washington, D. C.
Commonwealth, San Francisco.
Colorado School of Mines, Golden, Colorado.
Cooper-Bessemer Monthly, Grove City, Pennsylvania.
Engineering and Mining Journal, New York City.
Explosive Service Bulletins, Washington, Delaware.
Fuel Oil, Chicago, Illinois.
Fusion Facts, Whittier, California.
Graphite, Jersey City.
Grizzly Bear, Los Angeles.
Hercules Mixer, Wilmington, Delaware.
Independent Monthly, Tulsa, Oklahoma.
Industrial Employment Information Bulletin, Washington, D. C.
Lubrication, The Texas Co., New York City.
Mining Congress Journal, Washington, D. C.

Mining Journal, London.
Mining Journal, Phoenix, Arizona.
Mining and Metallurgy, New York City.
Mining Review, Salt Lake City.
Mining Truth, Spokane, Washington.
Monthly Review of Business Conditions, San Francisco.
National Sand and Gravel, Washington, D. C.
Oil Bulletin, Los Angeles.
Oil Field Engineering, Philadelphia, Pennsylvania
Oil and Gas Journal, Tulsa, Oklahoma.
Oil, Paint and Drug Reporter, New York City.
Oil Weekly, Houston, Texas.
Pit and Quarry, Chicago.
Pacific Purchaser, San Francisco.
Petroleum Times, London, E. C. 2.
Petroleum Age, Chicago.
Petroleum World, Los Angeles.
Queensland Government Mining Journal, Brisbane, Australia.
Record, Associated Oil Co., San Francisco.
Rock Products, Chicago.
Rocks and Minerals, Peekskill, New York.
Scientific American, New York City.
Southwest Builder and Contractor, Los Angeles.
Standard Oil Bulletin, San Francisco.
Stone, New York City.
Through the Ages, Baltimore.
Union Oil Bulletin, Los Angeles.

Newspapers.

The following papers are received and kept on file in the library:

Amador Dispatch, Jackson, California.
Barstow Printer, Barstow, California.
Beaumont Gazette, Beaumont, California.
Bridgeport Chronicle-Union, Bridgeport, California.
California Oil World, Los Angeles, California.
Calaveras Californian, Angels Camp, California.
Calaveras Prospect, San Andreas, California.
Colusa Daily Sun, Colusa, California.
Daily Commercial News, San Francisco, California.
Daily Midway Driller, Taft, California.
Del Norte Triplicate, Crescent City, California.
Denver Mining Record, Denver, Colorado.
Exeter Sun, Exeter, California.
Goldfield News, Goldfield, Nevada.
Inyo Independent, Independence, California.
Inyo Register, Bishop, California.
Ione Valley Echo, Ione, California.
Kettleman Oil and Gas News, Kettleman City, California.
Las Vegas Age, Las Vegas, Nevada.
Livermore Herald, Livermore. California.
Mariposa Gazette, Mariposa, California.
Mercury Register, Oroville, California.
Mojave Miner, Kingman, Arizona.
Mojave-Randsburg Record, Mojave, California.
Morning Union, Grass Valley, California.
Mountain Messenger, Downieville, California.
National Industrial Review, San Francisco, California.
Needles Nugget, Needles, California.
Nevada City Nugget, Nevada City, California.
Nevada Mining Press, Reno, Nevada.
Oil Refinery News, Bayonne, New Jersey.
Petroleum Press, Taft, California.

Placer Herald, Auburn, California.
Plumas Independent, Quincy, California.
San Diego News, San Diego, California.
Shasta Courier, Redding, California.
Siskiyou News, Yreka, California.
Sotoyome Scimitar, Healdsburg, California.
Stockton Record, Stockton, California.
Tehachapi News, Tehachapi, California.
Tuolumne Prospector, Tuolumne, California.
Ventura County News, Ventura, California.
Waterford News, Waterford, California.
Weekly Trinity Journal, Weaverville, California.
Western Mineral Survey, Salt Lake City, Utah.
Western Sentinel, Etna Mills, California.

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PRODUCERS AND CONSUMERS

The producer and consumer of mineral products are mutually dependent upon each other for their prosperity, and one of the most direct aids rendered by the Bureau to the mining industry in the past has been that of bringing producers and consumers into direct touch with each other.

This work has been carried on largely by correspondence, supplemented by personal consultation. Lists of buyers of all the commercial minerals produced in California have been made available to producers upon request, and likewise the owners of undeveloped deposits of various minerals, and producers of them, have been made known to those looking for raw mineral products.

When the publication of MINING IN CALIFORNIA was on a monthly basis, current inquiries from buyers and sellers were summarized and lists of mineral products or deposits 'wanted' or 'for sale' included in each issue.

It is important that inquiries of this nature reach the mining public as soon as possible and in order to avoid the delay incident to the present quarterly publication of MINING IN CALIFORNIA, these lists are now issued monthly in the form of a mimeographed sheet under the title of 'Commercial Mineral Notes,' and sent to those on the mailing list for MINING IN CALIFORNIA.

EMPLOYMENT SERVICE

Following the establishment of the Mining Division branch offices in 1919, a free technical employment service was offered as a mutual aid to mine operators and technical men for the general benefit of the mineral industry.

Briefly summarized, men desiring positions are registered, the cards containing an outline of the applicant's qualifications, position wanted, salary desired, etc., and as notices of 'positions open' are received, the names and addresses of all applicants deemed qualified are sent to the prospective employer for direct negotiations.

Telephone and telegraphic communications are also given immediate attention.

Technical men, or those qualified for supervisory positions, and vacancies of like nature only, are registered, as no attempt will be made to supply common mine and mill labor.

Registration cards for the use of both prospective employers and employees may be obtained upon request, and a cordial invitation is extended to the industry to make free use of the facilities afforded. Parties interested should communicate direct with our San Francisco office.

PUBLICATIONS OF THE DIVISION OF MINES

During the past fifty-one years, in carrying out the provisions of the organic act creating the former California State Mining Bureau, there have been published many reports, bulletins and maps which go to make up a library of detailed information on the mineral industry of the State, a large part of which could not be duplicated from any other source.

One feature that has added to the popularity of the publications is that many of them have been distributed without cost to the public, and even the more elaborate ones have been sold at a price which barely covers the cost of printing.

Owing to the fact that funds for the advancing of the work of this department have often been limited, many of the reports and bulletins mentioned were printed in limited editions which are now entirely exhausted.

Copies of such publications are available, however, in the office of the Division of Mines, in the Ferry Building, San Francisco; Bankers Building, Los Angeles; State Office Building, Sacramento; Redding; Santa Maria; Santa Paula; Coalinga; Taft; Bakersfield. They may also be found in many public, private and technical libraries in California and other states, and foreign countries.

A catalog of all publications from 1880 to 1917, giving a synopsis of their contents, is issued as Bulletin No. 77.

Publications in stock may be obtained by addressing any of the above offices and enclosing the requisite amount in the case of publications that have a list price. Only coin, stamps or money orders should be sent, and it will be appreciated if remittance is made in this manner rather than by personal check.

The prices noted include delivery charges to all parts of the United States. Money orders should be made payable to the Division of Mines.

NOTE.—The Division of Mines frequently receives requests for some of the early Reports and Bulletins now out of print, and it will be appreciated if parties having such publications and wishing to dispose of them will advise this office.

REPORTS

Asterisks (**) indicate the publication is out of print.

	Price
**First Annual Report of the State Mineralogist, 1880, 43 pp. Henry G. Hanks	----
**Second Annual Report of the State Mineralogist, 1882, 514 pp., 4 illustrations, 1 map. Henry G. Hanks	----
**Third Annual Report of the State Mineralogist, 1883, 111 pp., 21 illustrations. Henry G. Hanks	----
**Fourth Annual Report of the State Mineralogist, 1884, 410 pp., 7 illustrations. Henry G. Hanks	----
**Fifth Annual Report of the State Mineralogist, 1885, 234 pp., 15 illustrations, 1 geological map. Henry G. Hanks	----
**Sixth Annual Report of the State Mineralogist, Part I, 1886, 145 pp., 3 illustrations, 1 map. Henry G. Hanks	----
**Part II, 1887, 222 pp., 36 illustrations. William Irelan, Jr.	----

REPORTS—Continued

Asterisks (**) indicate the publication is out of print.

	Price
**Seventh Annual Report of the State Mineralogist, 1887, 315 pp. William Irelan, Jr.	----
**Eighth Annual Report of the State Mineralogist, 1888, 948 pp., 122 illustrations. William Irelan, Jr.	----
**Ninth Annual Report of the State Mineralogist, 1889, 352 pp., 57 illustrations, 2 maps. William Irelan, Jr.	----
**Tenth Annual Report of the State Mineralogist, 1890, 983 pp., 179 illustrations, 10 maps. William Irelan, Jr.	----
Eleventh Report (First Biennial) of the State Mineralogist, for the two years ending September 15, 1892, 612 pp., 73 illustrations, 4 maps. William Irelan, Jr.	$1.00
**Twelfth Report (Second Biennial) of the State Mineralogist, for the two years ending September 15, 1894, 541 pp., 101 illustrations, 5 maps. J. J. Crawford	----
**Thirteenth Report (Third Biennial) of the State Mineralogist, for the two years ending September 15, 1896, 726 pp., 93 illustrations, 1 map. J. J. Crawford	----
Chapters of the State Mineralogist's Report, Biennial Period, 1913–1914, Fletcher Hamilton:	
**Mines and Mineral Resources, Amador, Calaveras and Tuolumne Counties, 172 pp., paper	----
Mines and Mineral Resources, Colusa, Glenn, Lake, Marin, Napa, Solano, Sonoma and Yolo Counties, 208 pp., paper	.50
**Mines and Mineral Resources, Del Norte, Humboldt and Mendocino Counties, 59 pp., paper	----
**Mines and Mineral Resources, Fresno, Kern, Kings, Madera, Mariposa, Merced, San Joaquin and Stanislaus Counties, 220 pages, paper	----
**Mines and Mineral Resources of Imperial and San Diego Counties, 113 pp., paper	----
**Mines and Mineral Resources, Shasta, Siskiyou and Trinity Counties, 180 pp., paper	----
**Fourteenth Report of the State Mineralogist, for the Biennial Period 1913–1914, Fletcher Hamilton, 1915:	
A General Report on the Mines and Mineral Resources of Amador, Calaveras, Tuolumne, Colusa, Glenn, Lake, Marin, Napa, Solano, Sonoma, Yolo, Del Norte, Humboldt, Mendocino, Fresno, Kern, Kings, Madera, Mariposa, Merced, San Joaquin, Stanislaus, San Diego, Imperial, Shasta, Siskiyou and Trinity Counties, 974 pp., 275 illustrations, cloth	----
Chapters of the State Mineralogist's Report, Biennial Period, 1915–1916. Fletcher Hamilton:	
**Mines and Mineral Resources, Alpine, Inyo and Mono Counties, 176 pp., paper	----
Mines and Mineral Resources, Butte, Lassen, Modoc, Sutter and Tehama Counties, 91 pp., paper	.50
**Mines and Mineral Resources, El Dorado, Placer, Sacramento and Yuba Counties, 198 pp., paper	----
Mines and Mineral Resources, Monterey, San Benito, San Luis Obispo, Santa Barbara and Ventura Counties, 183 pp., paper	.65
**Mines and Mineral Resources, Los Angeles, Orange and Riverside Counties, 136 pp., paper	----
**Mines and Mineral Resources, San Bernardino and Tulare Counties, 186 pp., paper	----
**Fifteenth Report of the State Mineralogist, for the Biennial Period 1915–1916, Fletcher Hamilton, 1917:	
A General Report on the Mines and Mineral Resources of Alpine, Inyo, Mono, Butte, Lassen, Modoc, Sutter, Tehama, Placer, Sacramento, Yuba, Los Angeles, Orange, Riverside, San Benito, San Luis Obispo, Santa Barbara, Ventura, San Bernardino and Tulare Counties, 990 pp., 413 illustrations, cloth	----
Chapters of the State Mineralogist's Report, Biennial Period 1917–1918, Fletcher Hamilton:	
Mines and Mineral Rosources of Nevada County, 270 pp., paper	.75
Mines and Mineral Resources of Plumas County, 188 pp., paper	.50
Mines and Mineral Resources of Sierra County, 144 pp., paper	.50

REPORTS—Continued

Asterisks (**) indicate the publication is out of print.

	Price
Seventeenth Report of the State Mineralogist, 1920, 'Mining in California during 1920,' Fletcher Hamilton; 562 pp., 71 illustrations, cloth	$1.75
Eighteenth Report of the State Mineralogist, 1922, 'Mining in California,' Fletcher Hamilton. Chapters published monthly beginning with January, 1922:	
**January, **February, **March, **April, **May, **June, **July, August, September, October, **November, December, 1922	Free
Chapters of Nineteenth Report of the State Mineralogist, 'Mining in California,' Fletcher Hamilton and Lloyd L. Root. January, February, March, September, 1923	Free
Chapters of Twentieth Report of the State Mineralogist, 'Mining in California,' Lloyd L. Root. Published quarterly. January, April, **July, October, 1924, per copy	.25
Chapters of Twenty-first Report of the State Mineralogist, 'Mining in California,' Lloyd L. Root. Published quarterly:	
January, 1925, Mines and Mineral Resources of Sacramento, Monterey and Orange Counties	.25
April, 1925, Mines and Mineral Resources of Calaveras. Merced, San Joaquin, Stanislaus and Ventura Counties	.25
July, 1925, Mines and Mineral Resources of Del Norte, Humboldt and San Diego Counties	.25
October, 1925, Mines and Mineral Resources of Siskiyou, San Luis Obispo and Santa Barbara Counties	.25
Chapters of Twenty-second Report of the State Mineralogist, 'Mining in California,' Lloyd L. Root. Published quarterly:	
January, 1926, Mines and Mineral Resources of Trinity and Santa Cruz Counties	.25
April, 1926, Mines and Mineral Resources of Shasta, San Benito and Imperial Counties	.25
July, 1926, Mines and Mineral Resources of Marin and Sonoma Counties	.25
October, 1926, Mines and Mineral Resources of El Dorado and Inyo Counties, also report on Minaret District, Madera County	.25
Chapters of Twenty-third Report of the State Mineralogist, 'Mining in California,' Lloyd L. Root. Published quarterly:	
January, 1927, Mines and Mineral Resources of Contra Costa County; Santa Catalina Island	.25
April, 1927, Mines and Mineral Resources of Amador and Solano Counties	.25
July, 1927, Mines and Mineral Resources of Placer and Los Angeles Counties	.25
October, 1927, Mines and Mineral Resources of Mono County	.25
Chapters of Twenty-fourth Report of the State Mineralogist, 'Mining in California,' Lloyd L. Root. Published quarterly:	
January, 1928, Mines and Mineral Resources of Tuolumne County	.25
April, 1928, Mines and Mineral Resources of Mariposa County	.25
**July 1928, Mines and Mineral Resources of Butte and Tehama Counties	----
October, 1928, Mines and Mineral Resources of Plumas and Madera Counties	.25
Chapters of Twenty-fifth Report of the State Mineralogist, 'Mining in California,' Walter W. Bradley. Published quarterly:	
January, 1929, Mines and Mineral Resources of Lassen, Modoc and Kern Counties; also on Special Placer Machines	.25
April, 1929, Mines and Mineral Resources of Sierra, Napa, San Francisco and San Mateo Counties	.25
July, 1929, Mines and Mineral Resources of Colusa, Fresno and Lake Counties	.25
October, 1929, Mines and Mineral Resources of Glenn, Alameda, Mendocino and Riverside Counties	.25
Chapters of Twenty-sixth Report of the State Mineralogist 'Mining in California', Walter W. Bradley. Published quarterly:	
January, 1930, Mines and Mineral Resources of Santa Clara County; also Barite in California	.25
April, 1930, Mines and Mineral Resources of Nevada County; also Mineral Paint Materials in California	.25
**July, 1930, Mines and Mineral Resources of Yuba and San Bernardino Counties; also Commercial Grinding Plants in California	----

REPORTS—Continued

Asterisks (**) indicate the publication is out of print.

	Price
October, 1930, Mines and Mineral Resources of Butte, Kings and Tulare Counties; also Geology of Southwestern Mono County (Preliminary)	$0.25
Chapters of Twenty-seventh Report of the State Mineralogist, 'Mining in California', Walter W. Bradley. Published quarterly:	
January, 1931, Preliminary Report on Economic Geology of the Shasta Quadrangle. Beryllium and Beryl. The New Tariff and Nonmetallic Products. Crystalline Talc. Decorative effects in Concrete	.25
April, 1931, Stratigraphy of the Kreyenhagen Shale. Diatoms and Silicoflagellates of the Kreyenhagen Shale. Foraminifer of the Kreyenhagen Shale. Geology of Santa Cruz Island	.25
July 1931, Mines and Mineral Resources of Yuba and San Bernardino Counties, Feldspar, Silica, Andalusite, and Cyanite Deposits of California. Andalusite in Mono County. Trinity-Klamath River Fish and Game District affects Mining. U. S. Mint Aids Prospectors	.25
October, 1931, Mines and Mineral Resources of Alpine County. Geology of San Jacinto Quadrangle South of San Gorgonio Pass. Mining Activity in Inyo and Mono Counties	.25
Subscription, $1.00 in advance (by calendar year, only).	
Chapters of State Oil and Gas Supervisor's Report:	
Summary of Operations—California Oil Fields, July, 1918, to March, 1919 (one volume)	Free
Summary of Operations—California Oil Fields. Published monthly, beginning April, 1919:	
**April, **May, June, **July, **August, **September, **October, November, **December, 1919	Free
January, February, March, April, **May, June, July, **August, September, October, November, December, 1920	Free
January, **February, **March, **April, May, June, **July, August, **September, **October, **November, **December, 1921	Free
January, February, March, April, May, June, July, August, September, October, November, December, 1922	Free
January, February, March, April, May, June, July, August, September, October, November, December, 1923	Free
January, February, March, April, May, June, July, August, September, October, November, December, 1924	Free
January, February, March, April, May, June, July, August, September, October, November, December, 1925	Free
January, February, March, April, May, June, July, August, September, October, November, December, 1926	Free
January, February, March, April, May, June, July, August, September, October, November, December, 1927	Free
January, February, March, April, May, June, July, August, September, October, **November, **December, 1928	Free
January, February, March, April, May, June, July-August-September, October-November-December, 1929	Free
January-February-March, April-May-June, July-August-September, 1930 (Published quarterly beginning July, 1929.)	Free

BULLETINS

Asterisks (**) indicate the publication is out of print.

	Price
**Bulletin No. 1. A Description of Some Desiccated Human Remains, by Winslow Anderson. 1888, 41 pp., 6 illustrations	----
**Bulletin No. 2. Methods of Mine Timbering, by W. H. Storms. 1894, 58 pp., 75 illustrations	----
**Bulletin No. 3. Gas and Petroleum Yielding Formations of Central Valley of California, by W. L. Watts. 1894, 100 pp., 13 illustrations, 4 maps	----
**Bulletin No. 4. Catalogue of Californian Fossils, by J. G. Cooper, 1894, 73 pp., 67 illustrations. (Part I was published in the Seventh Annual Report of the State Mineralogist, 1887.)	----
**Bulletin No. 5. The Cyanide Process, 1894, by Dr. A. Scheidel. 140 pp., 46 illustrations	----
**Bulletin No. 6. California Gold Mill Practices, 1895, by E. B. Preston, 85 pp., 46 illustrations	----
**Bulletin No. 7. Mineral Production of California, by Counties, for the year 1894, by Charles G. Yale. Tabulated sheet	----
**Bulletin No. 8. Mineral Production of California, by Counties, for the year 1895, by Charles G. Yale. Tabulated sheet	----
**Bulletin No. 9. Mine Drainage, Pumps, etc., by Hans C. Behr. 1896, 210 pp., 206 illustrations	----
**Bulletin No. 10. A bibliography Relating to the Geology, Paleontology and Mineral Resources of California, by Anthony W. Vogdes. 1896, 121 pp.	----
**Bulletin No. 11. Oil and Gas Yielding Formations of Los Angeles, Ventura and Santa Barbara Counties, by W. L. Watts. 1897, 94 pp., 6 maps, 31 illustrations	----
**Bulletin No. 12. Mineral Production of California, by Counties, for 1896, by Charles G. Yale. Tabulated sheet	----
**Bulletin No. 13. Mineral Production of California, by Counties, for 1897, by Charles G. Yale. Tabulated sheet	----
**Bulletin No. 14. Mineral Production of California, by Counties, for 1898, by Charles G. Yale	----
**Bulletin No. 15. Map of Oil City Fields, Fresno County, by John H. Means. 1899	----
**Bulletin No. 16. The Genesis of Petroleum and Asphaltum in California, by A. S. Cooper. 1899, 39 pp., 29 illustrations	----
**Bulletin No. 17. Mineral Production of California, by Counties, for 1899, by Charles G. Yale. Tabulated sheet	----
**Bulletin No. 18. Mother Lode Region of California, by W. H. Storms. 1900, 154 pp., 49 illustrations	----
**Bulletin No. 19. Oil and Gas Yielding Formations of California, by W. L. Watts. 1900, 236 pp., 60 illustrations, 8 maps	----
**Bulletin No. 20. Synopsis of General Report of State Mining Bureau, by W. L. Watts. 1901, 21 pp. This bulletin contains a brief statement of the progress of the mineral industry in California for the four years ending December, 1899	----
**Bulletin No. 21. Mineral Production of California by Counties, by Charles G. Yale. 1900. Tabulated sheet	----
**Bulletin No. 22. Mineral Production of California for Fourteen Years, by Charles G. Yale. 1900. Tabulated sheet	----
Bulletin No. 23. The Copper Resources of California, by P. C. DuBois, F. M. Anderson, J. H. Tibbits and G. A. Tweedy. 1902, 282 pp., 69 illustrations, 9 maps	$0.50
**Bulletin No. 24. The Saline Deposits of California, by G. E. Bailey. 1902, 216 pp., 99 illustrations, 5 maps	----
**Bulletin No. 25. Mineral Production of California, by Counties, for 1901, by Charles G. Yale. Tabulated sheet	----
**Bulletin No. 26. Mineral Production of California for the Past Fifteen Years, by Charles G. Yale. 1902. Tabulated sheet	----
**Bulletin No. 27. The Quicksilver Resources of California, by William Forstner. 1903, 273 pp., 144 illustrations, 8 maps	----
**Bulletin No. 28. Mineral Production of California for 1902, by Charles G. Yale. Tabulated sheet	----

BULLETINS—Continued

Asterisks (**) indicate the publication is out of print.

	Price
**Bulletin No. 29. Mineral Production of California for Sixteen Years, by Charles G. Yale. 1903. Tabulated sheet	----
**Bulletin No. 30. Bibliography Relating to the Geology, Paleontology and Mineral Resources of California, by A. W. Vogdes. 1903, 290 pp.	----
**Bulletin No. 31. Chemical Analyses of California Petroleum, by H. N. Cooper. 1904. Tabulated sheet	----
**Bulletin No. 32. Production and Use of Petroleum in California, by Paul W. Prutzman. 1904, 230 pp., 116 illustrations, 14 maps	----
**Bulletin No. 33. Mineral Production of California, by Counties, for 1903, by Charles G. Yale. Tabulated sheet	----
**Bulletin No. 34. Mineral Production of California for Seventeen Years, by Charles G. Yale. 1904. Tabulated sheet	----
**Bulletin No. 35. Mines and Minerals of California, by Charles G. Yale. 1904, 55 pp., 20 county maps. Relief map of California	----
**Bulletin No. 36. Gold Dredging in California, by J. E. Doolittle. 1905. 120 pp., 66 illustrations, 3 maps	----
**Bulletin No. 37. Gems, Jewelers' Materials, and Ornamental Stones of California, by George F. Kunz. 1905, 168 pp., 54 illustrations	----
**Bulletin No. 38. Structural and Industrial Materials of California, by Wm. Forstner, T. C. Hopkins, C. Naramore and L. H. Eddy. 1906, 412 pp., 150 illustrations, 1 map	----
**Bulletin No. 39. Mineral Production of California, by Counties, for 1904, by Charles G. Yale. Tabulated sheet	----
**Bulletin No. 40. Mineral Production of California for Eighteen Years, by Charles G. Yale. 1905. Tabulated sheet	----
**Bulletin No. 41. Mines and Minerals of California for 1904, by Charles G. Yale. 1905, 54 pp., 20 county maps	----
**Bulletin No. 42. Mineral Production of California, by Counties, 1905, by Charles G. Yale. Tabulated sheet	----
**Bulletin No. 43. Mineral Production of California for Nineteen Years, by Charles G. Yale. Tabulated sheet	----
**Bulletin No. 44. California Mines and Minerals for 1905, by Charles G. Yale. 1907, 31 pp., 20 county maps	----
**Bulletin No. 45. Auriferous Black Sands of California, by J. A. Edman. 1907. 10 pp.	----
**Bulletin No. 46. General Index of Publications of the California State Mining Bureau, by Charles G. Yale. 1907, 54 pp.	----
**Bulletin No. 47. Mineral Production of California, by Counties, 1906, by Charles G. Yale. Tabulated sheet	----
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Samples (limited to three at one time) of any mineral found in the State may be sent to the Division of Mines for identification, and the same will be classified free of charge. No samples will be determined if received from points outside the State. It must be understood that no assays, or quantitative determinations will be made. Samples should be in lump form if possible, and marked plainly with name of sender on outside of package, etc. No samples will be received unless delivery charges are prepaid. A letter should accompany sample, giving locality where mineral was found and the nature of the information desired.

INDEX

Page
Acme Talc Mine, San Bernardino County — 400
Administrative — 112, 223, 467, 546
Abrams Schist in Shasta Quadrangle — 7
Afton fluorspar deposit, San Bernardino County — 375–376
  magnesite deposit, San Bernardino County — 390
Agates in San Bernardino County (see Gems).
  Shasta Quadrangle (see Gems).
Age of Kreyenhagen shale — 187, 206
Alameda County, oil field development operations in — 220, 404
  , silica in — 432
Albite (see Feldspar).
Albert Ranch feldspar deposit, Riverside County — 420–421
  silica deposit, Riverside County — 442
Alhambra Mining Corporation — 488
Allie and Beatrice property, San Bernardino County — 340
Allison garnet deposit, San Bernardino County — 381
Allured Copper Mine, San Bernardino County — 265
Alpine Cons. Mining Co. — 489
  County — 488–491
    mineral production of — 488
Alta Mine, San Bernardino County — 340
Altas Fire Brick Company (see Kennedy).
Altoona Quicksilver Mine, Trinity County — 63–64
Altuma Mine, San Bernardino County — 281
Alvord Mine, San Bernardino County — 281
Amador County, feldspar in — 415
  , silica in — 432–435
Amalgamated Mine, Siskiyou County — 29
Amargosa Group of Talc Mines, San Bernardino County — 399–400
Amazon Mines, San Bernardino County — 265
American Chemical Society cited — 394
  Eagle Group, San Bernardino County — 266
  Encaustic Tiling Company (see also Dehesa Cornwall stone deposit, San Diego County) — 421, 442, 445
  Hellenic Gold Mining Co. (see Wanderer Mine, San Bernardino County).
  Magnesium Company — 392
  Potash and Chemical Company — 392–394
Amick, W. D., silica property, Amador County — 433–434
Anaco Mine, San Bernardino County — 340–341
Anaconda Mine, San Bernardino County — 281
Analyses of sand from Crystal Silica Sand Company — 447
Analysis of alumina-silicate rock in Los Angeles County — 417
  bentonite from Balch deposit — 379
    deposit of Carewe-Norton deposit — 380
  clay from Le Feure deposit — 374
  Cornwall stone from Dehesa deposit — 428
  cyanite from Obilby deposits — 457
  dumortierite in San Diego County — 452
  feldspar from Nine-Mile Canyon deposit — 416
    Pacific Mine — 431
  fluorspar from Afton deposit — 376
  magnesite from Afton deposit — 390
  quartz from Machado deposit — 443
  sand from Barber (Shepard) pit — 434
  silica and feldspar from Flynt Silica and Spar Company's deposit — 429
    clay from Hill Bros. Chemical Company deposit — 391
    from Burroughs deposit — 446
      Fish Mountain deposit — 438
      Hammonds deposit — 450
      Muroc deposit — 438
      Penny deposit — 444
      Quartz Mountain deposit — 439
    sand from Temescal Canyon deposit — 444
Andalusite, cyanite, dumortierite and sillimanite — 450–458
  in Fresno County — 452
    Kern County — 452
    Mariposa County — 452
      Mono County — 453–455, 459–464
        , geology of — 459–460
        , mining methods — 461–462
        , plant processes — 462–464
        , technical importance — 464
    Nevada County — 455
    Riverside County — 455
  (see also Feldspar).
  , uses of — 451

Page
Anderson, F. M. ---- 11
, cited ---- 150, 153, 170, 178
, Robert, cited ---- 152, 156, 158, 159, 162, 175
Andesite, diorite porphyry and dacite in Shasta Quadrangle ---- 23
Anorthite (see Feldspar).
Antimony in San Bernardino County ---- 264–265
Apex Mine, San Bernardino County ---- 281–282
Appropriations ---- 467
Archer silica deposit, Shasta County ---- 450
Arcturas Mine, San Bernardino County (see Ibex).
Areal geology of Shasta Quadrangle ---- 6
Argosy Mine, San Bernardino County ---- 364
Arlington Mines, San Bernardino County ---- 282–286
Mining Corporation ---- 382
Armistice claim, San Bernardino County ---- 286
Armstrong Mining Company (see Sidewinder Mine, San Bernardino County).
Arnold, Ralph, cited, ---- 152, 154, 155, 156, 498, 517
Arrowhead Development Company (see Supply Mine, San Bernardino County).
Gold Mining Company (see C. H. and P. A. Group, Halloran Springs Mining District, San Bernardino County) (also Gold Pine group of claims, Halloran Springs Mining District) (also Prince group of claims) (also Utah group of claims).
Arroyo Ciervo Locality, Foraminifera of ---- 203
Seco Grant, sand and clay deposits, Amador County ---- 434
Asbestos in San Bernardino County ---- 370–371
Shasta Quadrangle ---- 26
Asgood Group, Siskiyou County (see Lucky Strike Group).
Atolia Mining Company ---- 365–366
Avawatz Crown Mine, San Bernardino County ---- 341
Salt and Gypsum Company (see also Strontium) (also Sheep Creek talc deposits, San Bernardino County) ---- 395–396
Averill, Chas. V. ---- 1–65, 129–138, 245, 487
Bagdad-Chase Mine, San Bernardino County ---- 266
Bailey, Thomas, cited ---- 179, 181
Baker limestone deposit, San Bernardino County ---- 383
Balch bentonite deposit, San Bernardino County ---- 379
Bald Eagle Mining Company ---- 287
Baltic Group, San Bernardino County (see Calico-Odessa Group of Mines).
Bank Roll and Green Gold Groups, San Bernardino County ---- 341
Barber bentonite deposit, San Bernardino County ---- 380
(Shepard) sand pit, Amador County ---- 434
Bardin feldspar deposit, Monterey County ---- 420
Barite in San Bernardino County ---- 371–373
Shasta Quadrangle ---- 26– 27
Barium Queen Mine, San Bernardino County ---- 371
Barrett Mine, San Bernardino County ---- 287
Barundum prospect, Siskiyou County ---- 29
Barytes ---- 224
Basalt, photo. of ---- 25
Bastin, Edson S., cited ---- 92
Baxter and Ballardie Quarries, San Bernardino County ---- 383
fluorspar deposit, San Bernardino County ---- 376
Bay Development Company (see Lapis sand plant, Monterey County).
Beal, C. H., cited ---- 498
Bean Boys Hydraulic Mine, Yuba County ---- 258
Beehhive or Mount Hope Mine, Yuba County ---- 249
Beeman silica deposit, San Diego County ---- 445
Belcher Extension Mining Company ---- 341
Belgium claim, San Bernardino County (see Ord Mountain Mine)
Bell Gilroy Mine, San Bernardino County ---- 341
Belmont Mine, San Bernardino County ---- 287–288
Ben Hur Mine, San Bernardino County ---- 342
Benton Ranch silica deposit, San Diego County ---- 445
Bentonite in San Bernardino County (see Fullers earth)
Beryl, uses of ---- 89
, occurrences of ---- 89– 95
Beryllium and Beryl ---- 83– 97
, uses ---- 85– 86
Bessemer claim, San Bernardino County (see Iron Mountain iron deposit).
Bevis Divide Mining Company ---- 342
Bibliography and Review of Previous work Bearing on the Kreyenhagen Shale Problem ---- 149
Big Blue Group, San Bernardino County (see North Star).
Butte Mine, San Bernardino County ---- 266
Four Mine, San Bernardino County ---- 342
Horn Group, San Bernardino County ---- 288
Ledge Mine, Yuba County (see Kingbird Mine).
Medicine barite deposit, San Bernardino County ---- 371
Pine limestone deposit, San Bernardino County ---- 383
Six property, San Bernardino County ---- 342
Ten Mine, San Bernardino County (see Ozark Mine).
Bismark Group, San Bernardino County (see Calico-Odessa Group of Mines).
Mine, San Bernardino County ---- 342
Bituminous rock ---- 224

Page

Black Basin sodium sulphate deposit, San Bernardino County 398
Diamond Mine, San Bernardino County 266
Foot-Golconda Group of Mines, San Bernardino County 342
Hawk Mine, San Bernardino County (see Arlington Mines).
Tungsten Mine, San Bernardino County 366–367
Metal Mine, San Bernardino County 266
Mountain Mining Company 266
Stone manganese deposit, San Bernardino County 337
Water Mine, San Bernardino County (see Silver Lode).
Blake, W. P., cited 452
Blanca Tuff of Santa Cruz Island 217
Blue Channel Mine, Siskiyou County 56
Jacket Mine, San Bernardino County (see Hermit Mine).
prospect, Trinity County 29
Jay property, Trinity County 29
Bob Lee and Hattie Groups, San Bernardino County 342
Bodie District Activities in July, 1931 543
Bonanza King claims, Trinity County 29
Mine, San Bernardino County 342
Borates statistics for 1930 225
Borax in San Bernardino County 392
Borden silica deposits, San Diego County 446
Borosolvay plant, San Bernardino County 394
Boulder Hill Group, Alpine County 489
Bradley, Walter W. 112, 223, 467, 546
Bragdon Formation in Shasta Quadrangle 9
Brandon silica deposit, El Dorado County 437
Brannigan Mine, Halloran Springs Mining District, San Bernardino County 324–325
, San Bernardino County 289–290
Bray and Bisbee (Rand Silver King Mining Company), San Bernardino County 343
Brilliant claim, San Bernardino County (see Ord Mountain Mine).
Brine and Weiss silica deposit, San Bernardino County 444
Britton Ranch feldspar deposit, Tulare County 432
Brooklyn and Los Angeles Mines, San Bernardino County (see Brannigan Mine).
Brown, J. S., cited 493
John S., cited 250
Ranch feldspar deposit, Riverside County 421–422
silica deposit, Riverside County 442
Buchanan silica property, Madera County 439
Buckeye Tungsten Mine, San Bernardino County 367
Building stone in Shasta Quadrangle 65
Bullion Mine, San Bernardino County 343
Bumper Group, San Bernardino County, 266
Burcham Group, San Bernardino County (see Total Wreck Mine).
Burner Mines, Trinity County 30
Burnham Chemical Company 394–395
Burroughs Silica Mine, San Diego County 446
Bush, R. D. 78–82, 220–221, 404–406 541
Byron, Contra Costa County, Foraminifera of 203
C. H. and P. A. (Sunset) Group, Halloran Springs Mining District, San Bernardino County 325
Cadiz Dry Lake salt deposits, San Bernardino County 396
Cajon limestone deposit, San Bernardino County 383
Calarivada Mine, San Bernardino County 266–267, 343
Calaveras County, silica in 435–436
Calcium fluoride in San Bernardino County (see Fluorspar).
Calico-Odessa Group of Mines, San Bernardino County 343–345
California-American Mining Company (see Barrett Mine, San Bernardino County).
Coeur d'Alene Mining Company 345
Gold Copper Company 267
Land and Mineral Company (see American Encaustic Tiling Company).
Mother Lode Mine, Yuba County 248
Portland Cement Company's limestone plant and quarry, San Bernardino County 384
Rand Silver Company (see Wortley Consolidated Mines Company).
Mine, San Bernardino County 345–346
Reserve Company (see Lena Louise Garnet Group, San Bernardino County).
Rock Salt Company 396
Silica Company (see Hammond's silica deposit, Stanislaus County).
Talc Company's bentonite deposit, San Bernardino County 380
(see, also, Horner bentonite deposit).
Vanadium Company (see Lombard and Main Group, San Bernardino County).
Caliproducts Company's feldspar and silica deposit, Los Angeles County 417–418
Calmont Mine, San Bernardino County 290
Camp Castle Mine, San Bernardino County 290–291
Rock Placer Mine, San Bernardino County 291
Vera Group, San Bernardino County 267
Campbell Gold Lease Company (see Brannigan Mine, San Bernardino County).
Canoas Creek, Foraminifera of 204

Page

Carbonate group of claims, San Bernardino County ---- 367
Hill Group, San Bernardino County ---- 347
King Mine, San Bernardino County ---- 347
Carbonate Mine, San Bernardino County ---- 346–347
Carboniferous (Mississippian) in Shasta Quadrangle ---- 9
Carewe-Morton Enterprise Company ---- 380
Carlile clay and sand deposit, Amador County ---- 434–435
Carlsbad Group, San Diego County ---- 427, 446
Carr's Iron-Capped Dike, Trinity County ---- 30
Carter feldspar deposit, Tulare County ---- 432
Castle Crags, photo of ---- 19, 22
Cave Canyon iron deposit, San Bernardino County ---- 333–334
Springs Mining Corporation (Imperial Lode Mines) (see also Imperial Lode Lease, San Bernardino County) ---- 347–348
Celestite in San Bernardino County (see Strontium).
Celsian (see Feldspar).
Cement in San Bernardino County (see Limestone).
statistics for 1930 ---- 226
Central claim, San Bernardino County (see Ord Mountain Mine)
Mine, Siskiyou County ---- 30
Chalmers dolomite deposit, San Bernardino County ---- 384
Champion Sillimanite, Inc. ---- 453–455
Chart, correlation, Kreyenhagen Shale ---- opp. page 186
Cherry Hill Mine, Siskiyou County ---- 31
Chesterfield and Old Gold group of claims, Halloran Springs Mining District, San Bernardino County ---- 325
Chiastolite (see Andalusite).
Chicago-Pacific feldspar and silica deposit, Los Angeles County ---- 418
Chicken Hawk prospect, San Bernardino County ---- 348
Chico Formation in Shasta Quadrangle ---- 10, 11
Childers feldspar and silica deposit, Fresno County ---- 415
Chlorite Schist in Santa Cruz Island ---- 215
Christie Mine, San Bernardino County ---- 291
Chromite in Shasta Quadrangle ---- 27
Church, C. C. ---- 202–213
cited ---- 179
Cima limestone deposit, San Bernardino County ---- 384–385
Clark, Bruce L., cited ---- 166, 169, 172, 174, 177, 178, 181
sand pit, Amador County ---- 435
Claw Hammer Group, San Bernardino County ---- 267
Clay Corporation of California ---- 442
in San Bernardino County ---- 373–375
Claypole, E. W., cited ---- 498
Clement and Blackburn feldspar deposit, San Bernardino County ---- 426
Cliff Mine, San Bernardino County (see Arlington Mines).
Clipper Mountain Mine, San Bernardino County ---- 291
Cloos, Hans, cited ---- 510
Coahuila Brave feldspar and silica deposit, Riverside County ---- 422
silica deposit, Riverside County ---- 443
Coal in Shasta Quadrangle ---- 27
Coalmine Creek, Northwest of Coalinga, Foraminifera of ---- 204
Coin Stock group of claims, Halloran Springs Mining District, San Bernardino County ---- 325
Colorado Fuel and Iron Company (see Iron Mountain Group, San Bernardino County).
Colorado No. 2 Mine, Alpine County ---- 490
Colosseum Gold Mines Corporation (see Mojave Tungsten Mine, San Bernardino County).
Colosseum Mine, San Bernardino County ---- 291–292
Mines Corporation (see Calarivada Mine, San Bernardino County).
Columbia Cement Company (see Coyote Mountain silica deposit, Imperial County).
Mine, San Bernardino County ---- 267, 293, 348
Colossus Mining Co. ---- 490
Colusa County, oil field development operations in ---- 404
Commodore Mine, Siskiyou County ---- 31, 32
Commonwealth Group, San Bernardino County (see also Randsburg Associated Mines, Inc.) ---- 348
Concrete, Decorative Effects in ---- 105–111
Condit, D. Dale, cited ---- 180
Confidence Copper Mine, San Bernardino County ---- 269
Conglomerate of Santa Cruz Island ---- 217
Connolly, Joseph P., cited ---- 92
Consolidated Metals Company (see California Rand Silver Mine, San Bernardino County).
Corporation (see Wilshire Bishop Creek Mine).
Consumers and Producers ---- 127–244
Contact claim, Halloran Springs Mining District, San Bernardino County ---- 326
Contention Group, San Bernardino County (see Mabel).
Contra Costa County, silica in ---- 436–437
Coolgardie Placer Mines, San Bernardino County ---- 293
Coon Hollow placer mines, El Dorado County ---- 437
Coors kaolin deposit, San Bernardino County ---- 373
Copley meta-andesite in Shasta Quadrangle ---- 15

Page
Copper Basin Consolidated Mines Company 267
Bell Group, San Bernardino County 267–268
Commander Group, San Bernardino County 268–269
in San Bernardino County 265–280
Alpine County 491
Shasta Quadrangle 27–28
Queen prospect, Trinity County 32
World Mine, San Bernardino County 269
Cornish stone in San Bernardino County (see McKnight, H. E.)
Cornwall stone in San Diego County (see Dehesa).
Correlation chart, Kreyenhagen Shale opp. page 186
Correlations of Geologic Units, Kreyenhagen Shale 146
Cory prospect 32
Costs of Cyanide Treatment of Gossan 138
Couchman gypsum deposit, San Bernardino County 382
Coupon claim, San Bernardino County (see Ord Mountain Mine).
Coyote Mine, San Bernardino County (see California Silver Mine) 348
Mountain silica deposit, Imperial County 438
Cretaceous, Upper, in Shasta Quadrangle 10, 11
Cronese asbestos deposit, San Bernardino County 370
Crucible Mining Co. (see Gunter Canyon Barite Deposit).
Crystal claim, San Bernardino County (see Darling Mine).
Silica Sand Company 446–448
Crystalline Talc 100–104
Cummings and Wolf silica sand deposit, Stanislaus County 450
Cunningham, George M., cited 172
Cuprodescloizite in San Bernardino County (see Vanadium).
Curtz Cons. Mining Company 489
Cushman, J. A., cited 175, 176
Cuve Mine, San Bernardino County 348
Cyanide Treatment of Gossen, The Mountain Copper Company, Ltd. 129–138
Cyanite (see also Feldspar) (also Andalusite) in Imperial County 455–457
Los Angeles County 457
Tuolumne County 457
, uses of 451
D. and W. (Dayton and Wilber) Mine, San Bernardino County 269
Dacite in Shasta Quadrangle 23
Daggett Reduction Company 348
Dale Dry Lake sodium sulphate deposit, San Bernardino County 398
Dall, William Healey, cited 153
Danby Dry Lake salt deposit, San Bernardino County 396
Darling Mine, San Bernardino County 293
Davenport silica deposit, Placer County 442
Death Valley Mine, San Bernardino County 348–349
Decorative Effects in Concrete 105–111
Definition of Kreyenhagen Shale 142
Deformation tests of feldspar-biotite mixtures 411
Dehesa Cornwall stone deposit (feldspathic), San Diego County 427–428, 448
Del Monte Products Company 440
Delphos claim, San Diego County (see Burroughs Silica Mine).
Description of San Bernardino County 262
Descriptive geology of Shasta Quadrangle 6
Desert Antimony Mine, San Bernardino County 264–265
Butte Group, San Bernardino County 269, 271
Gold Placers, San Bernardino County 293
Mercury group of claims, San Bernardino County 339
Queen claim, San Bernardino County (see Cave Springs Mining Corporation).
Copper Mines Company 271
Devils Den-Wagonwheel Mountain Area, Foraminifera of 204
Dewey Mine, Siskiyou County 32
property 32
Diagrammatic sketch showing sequence of geologic formation, San Jacinto Mountain 505
Diamond G group of claims, Halloran Springs Mining District, San Bernardino County 326
Diatoms and Silicoflagellates of the Kreyenhagen Shale 187–201
Dickenson, R. E., cited 508
Dickerson, Roy E., cited 161, 165
Dietrich, W. F., cited 434, 435, 451
Diller, J. S., cited 3, 5, 8, 9, 10, 11, 15, 16, 24
Diorite in Shasta Quadrangle 20
porphyry in Shasta Quadrangle 23
District Reports of Mining Engineers 1–66 129–139, 245–401, 487–491
Dolomite in San Bernardino County (see Limestone).
Domengine Formation of Santa Cruz Island 216
Dorleska Mine, Trinity County 32
Dos Cabezas feldspar deposits, San Diego County 428
silica deposits, San Diego County 448
Drumlummon Claim, Alpine County 490
Dual Type Locality, Kreyenhagen Shale 143
Dumble, E. T., cited 159

Page
Dumortierite (see, also, Andalusite) in Imperial County 452
in Riverside County 452
San Diego County 452
, uses of 452
Duncan feldspar deposit, Los Angeles County 418–419
Easy Money prospect, Yuba County 249
Economic geology of Shasta Quadrangle 26
El Dorado County, silica in 437–438
Eldridge, G. H., cited 150
Elftman, H. O., cited 169
Eliza Mine, Siskiyou County 32– 34
Elkhorn Mining Company 293–294
Ellingford Nipton Group, San Bernardino County 349
Embody Mine, San Bernardino County 294
Emerson Mine, San Bernardino County 294
sodium sulphate deposit, San Bernardino County 398
Emma group of manganese claims, San Bernardino County 337
Emperor Mine, San Bernardino County 271
Empire Mines (copper), Siskiyou County 28
Employment service 127, 244, 486, 562
Emsco ganister deposits, San Bernardino County 376–377, 444–445
English, Walter A., cited 166, 168
Ensley-Spaulding feldspar and silica deposits, Riverside County 422
silica deposit, Riverside County 443
Eocene in Santa Cruz Island 215
Equitibus Mine, San Bernardino County 294–295
Evan Davis Mine, San Bernardino County 295
Establishment of Trinity and Klamath River Fish and Game District affects mining 465–466
Exchequer Mine, San Bernardino County 295
Extent of Thickness of Surface Exposures, Kreyenhagen Shale 147
Fan Shell Beach Workings, Monterey County (see Del Monte Products Company).
Faults of Santa Cruz Island 218
Fawcett Mines Co., Siskiyou County 57
Federal Company 367
Departments, Record of Progress By 67–73
Paymaster claim, San Bernardino County (see Federal Company).
Reserve claim, San Bernardino County (see Federal Company).
Feldspar and silica in Amador County 415
Fresno County 415
Inyo County 415–416
Kern County 416–417
Los Angeles County 417–419
Madera County 419
Mariposa County 419–420
Monterey County 420
Plumas County 420
Riverside County 420–426
San Bernardino County 376–377, 379, 426–427
San Diego County 427–431
Tulare County 432
, silica, andalusite, and cyanite deposits of California 407–464
statistics for 1930 226
Fidelity Metals Corporation 34
Fish and Game District, Trinity and Klamath River, affects mining 465–466
Mountain silica deposit, Imperial County 438
Flat Tire Group, San Bernardino County 350
Fluorspar in San Bernardino County 375–376
Flynt Silica and Spar Company 428–429, 448
Folds of Santa Cruz Island 219
Foraminifera of the Kreyenhagen Shale 202–213
Foshay Pass barite deposit, San Bernardino County 371
Foster Mine (Glory Group of Mines), San Bernardino County 271
Fox Lease, San Bernardino County 350
Fraction claim, San Bernardino County (see Elkhorn Mining Company).
Francis Copper Mine, San Bernardino County 271–272
Franke, Herbert A. 115–126, 232–243, 472–484, 551–561
Fraser, Donald McCoy 494
Free, E. E., cited 498
Fremont Peak Mine, San Bernardino County 295
Fresno County, andalusite in 452
Oil Field Development Operations 78, 220, 404, 541
Frick, Childs, cited 498, 512
Friday and Saturday group of claims, Halloran Springs Mining District, San Bernardino County 326
Friendship claim (see Yellow Rose Mine, Trinity County).
Frisco Group of Mines, San Bernardino County 295–296
Fullers earth in San Bernardino County 379–381
Gabb, W. M., cited 149
Gabbro in Shasta Quadrangle 18
Ganister in San Bernardino County (see Millet clay deposit); (also Emsco); (also Kennedy or Altas Fire Brick Company).

Page
Garfield Lease, San Bernardino County 350
Odessa Group, San Bernardino County (see Calico-Odessa Group of Mines).
Garnet in San Bernardino County 381–382
Garretson Springs 62
Garvan Mining and Reduction Company, Ltd. (see Grand View Mine, San Bernardino County).
Gates Chemical Company's feldspar deposit, Los Angeles County 419
Gem Quarry, San Bernardino County (see Verde Antique Marble Quarry).
Gems in San Bernardino County 381
Shasta Quadrangle 28–29
Geography of Yuba County 246
Geologic Branch 67–77, 140–219, 402–403, 492–540
progress report 492
Map of California 71
San Jacinto Quadrangle, Riverside County 541
Santa Cruz Island opp. page 218
Geology, areal, of Shasta Quadrangle 6
descriptive, of Shasta Quadrangle 6
economic, of Shasta Quadrangle 26
historical, of Shasta Quadrangle 5
of andalusite deposit in Modoc County 459–460
Halloran Springs Mining District, San Bernardino County 323
iron deposits in San Bernardino County 333–337
San Jacinto Quadrangle south of San Gorgonio Pass 494–540
(Introduction, 495; Geomorphology, 502; Geologic Formation 504; Geologic History, 536; General Features, 499; Petrology, 525; Structural Features, 516.)
Santa Cruz Island, Santa Barbara County, California, Preliminary Report of 214–219
the Shasta Quadrangle, Preliminary Report on 3–65
Yuba County 246–248
Gester, G. C. cited 172
Giant Ledge Gold and Copper Mine, San Bernardino County 272
Gilfeather prospect, Siskiyou County 34
Gladding, McBean and Company 442
's clay deposit, San Bernardino County 373–374
Gladstone Gold Mine San Bernardino County (see Mowry Mines Company).
Glidden barite deposit, Shasta County 26–27
Globe Mine, San Bernardino County 296
Tile and Porcelain Company (see White Rose Mine, San Diego County).
Glory Group of Mines, San Bernardino County (see Foster Mine).
Golconda Group, San Bernardino County (see Black Foot).
Gold an Nickel Group, Siskiyou County 34–35
Bar group of claims, Halloran Springs Mining District, San Bernardino County 326
Mine, San Bernardino County 296
Belt Mine, San Bernardino County 296–297
Bronze Mine, San Bernardino County 297
Bug claim, Halloran Springs Mining District, San Bernardino County 326
Bullion Mine, San Bernardino County 297
Dollar prospect, Trinity County 35
Dredges Incorporated, Limited 255
dredging in Yuba County 253–258
Eagle Mine, San Bernardino County 297
in Mill Tailings, Table of, The Mountain Copper Company, Ltd. 137
San Bernardino County 280–333
Shasta Quadrangle 29–60
Yuba County 248–258
King Mines, San Bernardino County 297, 298
lode mines in Shasta Quadrangle 29–55
Mountain Mine, San Bernardino County 298
Peak Mine, San Bernardino County (see Gold Belt Mine).
Pin group of claims, Halloran Springs Mining District, San Bernardino County 326–327
placer mines in Shasta Quadrangle 56–60
Yuba County 252–253
quartz mines in Yuba County 248–252
Reef Mines, San Bernardino County 298
Road group, Siskiyou County 40–41
Rose Mine, San Bernardino County 298–299
Streak group of claims, Halloran Springs Mining District, San Bernardino County 327
Golden Age prospect, Siskiyou County 35
Eagle claim, Siskiyou County (see Golden Age prospects).
Eagle Mine, Siskiyou County 35–37
Era property, San Bernardino County (see Elkhorn Mining Company).
Jubilee Mine Trinity County 35, 39–40
King Mining and Milling Company (see Yankee Maid Mine, San Bernardino County).
State Portland Cement Company's plant, San Bernardino County 385
Gold production of leading counties 1880-1930, incl. 548
Goldstone Mine, San Bernardino County 299

Page
Good Hope Mine, Alpine County 490
Title Mine, Yuba County 248
Goodale feldspar deposit, Tulare County 432
Goodyear, W. A., cited 214
Gossan, Cyanide Treatment of, The Mountain Copper Company, Ltd. 129–138
Gould talc deposit, San Bernardino County 400
Grady and Sill Lease, San Bernardino County 350
No. 2 and No. 1 Mines, San Bernardino County (see Navajo and Swastika Mines).
Grand View Mine, San Bernardino County 299
Granodiorite (and diorite) in Shasta Quadrangle 20
Gravel in Yuba County (see Miscellaneous stone).
Great Gold Belt Mine, San Bernardino County (see Camp Castle Mine).
Western Mining and Milling Co. (see Wortley Consolidated Mines Company).
Green Gold Group, San Bernardino County (see Bank Roll).
Greenstone and Copley meta-andesite in Shasta Quadrangle 15
Gumboot Mine Siskiyou County 41
Gunter Canyon Barite Deposit, Inyo County 545
Gustave Group, San Bernardino County 367
Guthrie silica deposit, Tulare County 450
Gypsum in San Bernardino County 382
statistics for 1930 226
, uses of 226
Gypsy Queen Mine, San Bernardino County 300
Halberg's Gold Mine, San Bernardino County (see Mowry Mines Company).
Halloran Group, San Bernardino County (see Black Hawk Tungsten Mine).
Springs Mine, San Bernardino County 273
Mining District, San Bernardino County 321–333
Hamburger Placer Group, San Bernardino County 300
Hammerback and Patterson Group of Mines, San Bernardino County (see Barrett Mine).
Hamilton feldspar deposit, Mariposa County 419–420
Hammon Engineering Company (see Too Handy Mine, Yuba County); (also Yuba Consolidated Gold Fields).
Hammonds silica deposit, Stanislaus County 450
Hanna, G. D. 187–201
cited 170, 171, 172, 173, 175, 178, 179
Hansen barite deposit, San Bernardino County 371–372
Harris, T. F., cited 382
Harrison Stock Farm feldspar and silica deposit, Fresno County 415
Hart Mine, Mariposa County (see Sebastopol Mine).
Harvard Mine, Tuolumne County 450
Hathaway Prospect, Siskiyou County 42
Hattie Group, San Bernardino County (see Bob Lee).
Hazel Mine, Siskiyou County 42–43
Headlight Mine, Trinity County 43
Hello Al Group, San Bernardino County 301
Hematite Gold Group, San Bernardino County (see Rincon Mines Company).
Hemet Silica Mine, Riverside County 443
Valley and vicinity, Map of 500
Hemstreet and Bell sand and gravel plant, Yuba County 259
Henry, Gerard, cited 174
George Mine, Yuba County 248
Henshaw Mine, San Bernardino County (see Murray Mining Company).
Hercules Group, San Bernardino County 273
Hermit Mine, San Bernardino County 273
Herndon Mine, Siskiyou County 58
Hershey, O. H., cited 5, 7
Hicks asbestos deposit, San Bernardino County 370–371
Hidden Hill Mine, San Bernardino County 273, 301
Treasure claim, San Bernardino County (see Elkhorn Mining Company).
Copper Mine, San Bernardino County 273
manganese claims, San Bernardino County (see Red Cross).
Hill Bros. Chemical Company 391
, R. T., cited 498, 517, 518
Hillside group of claims, Halloran Springs Mining District, San Bernardino County 327
Hinkley dolomite deposit, San Bernardino County 385
Historical geology of Shasta Quadrangle 5
History of San Bernardino County 262
Hodge, Edwin T., cited 526
Holcomb Valley Placers, San Bernardino County 301–302
Holland Mine, Trinity County 58
Holliman and Murphy clay deposit, San Bernardino County 374
Home Mine, San Bernardino County 273
Hongkong claim, San Bernardino County (see Desert Antimony Mine).
Honora Realty Company 432
Hoosier and Missouri Groups, San Bernardino County 273
Hoots, H. W., cited 180
Horner bentonite deposit, San Bernardino County 380–381
Hornet Mine, Shasta County (see Mountain Copper Company, Ltd., The).
Horse Creek Cinnabar Co., Ltd., Siskiyou County 64
Horseshoe Mine, Yuba County 249–250
Hudson, F. S., cited 510
Hulin, C. D., cited 345

Page
Humboldt County, oil field development operations in 404
Ibex Mine or Arcturas, San Bernardino County 350
Idria quicksilver group of claims, San Bernardino County 339–340
Igneous rocks in Shasta Quadrangle 17
Illig, Kurt, cited 85, 87, 88
Imperial County, cyanite in 455–457
, dumortierite in 452
, oil field development operations in 404
, silica in 438
group of claims, Halloran Springs Mining District, San Bernardino County 327
Lode Lease, San Bernardino County 350–351
Mines, San Bernardino County (see Cave Springs Mining Corporation).
Index map of California classifying topographic maps from various sources 68
Indian Trail Mine, San Bernardino County 351
Integral Quicksilver Mine, Trinity County 64
Investment Group, San Bernardino County (see Mabel).
Inyo and Mono Counties, Notes on Mining Activities in July, 1931 543
County, feldspar and silica in 415–416
, sillimanite in 457
Ione Fire Brick Company 435
Iridium in Yuba County (see Platinum group metals).
Irish group of claims, San Bernardino County 367
Iron Age iron deposit, San Bernardino County 334
Hat Group, San Bernardino County 334
in San Bernardino County 333–337
King Group of claims, Halloran Springs Mining District, San Bernardino County 327
Mountain Group, San Bernardino County 335
iron deposit, San Bernardino County 335
Rock Mines, Calaveras County 435–436
Ironclad Group, San Bernardino County (see Iron Hat Group).
Isabella Copper Mine, Siskiyou County 28
Ivanhoe Mine, San Bernardino County 302
Ivanpah Copper Company (see Copper World Mine, San Bernardino County) (also Mohawk Mine, San Bernardino County) (also Sagamore Mine, San Bernardino County).
Mammoth Mine, San Bernardino County 273
Mine, San Bernardino County 273
Jachon Mine, San Bernardino County 274
Jack Frost limestone deposit, San Bernardino County 385
Jeffery, Dr. J. A., and Woodhouse, C. D. 459–464
Jenkins, Olaf P. 67–73, 140–186, 402–403, 492
, Olaf P., cited 178, 180
Jennie Tonge feldspar deposit, Monterey County 420
Jens feldspar deposit, Monterey County 420
Jillson Mine, Siskiyou County (see Hazel Mine).
Jim Boy group of claims, San Bernardino County 302
Joburg Divide prospect, San Bernardino County 351
Johannesburg Mining and Milling Company 351
Johnson and Lewis Group, Siskiyou County 43
Bros. feldspar deposit, Monterey County 420
Harry R., cited 155
Johnson's Mine, San Bernardino County 302–303
Jones Brothers Asbestos Mine, Trinity County 26
sand deposit, Riverside County 443
Josephine claim, San Bernardino County (see Ord Mountain Mine).
Josie K. Mine, San Bernardino County 274
Juanita Group, San Bernardino County 274
Mine, San Bernardino County 274
Jubilee Mine (see Golden Jubilee).
June group of claims, San Bernardino County 303
Jurassic in Shasta Quadrangle 10
K. and K. Ranch feldspar and silica deposit, Riverside County 422
silica deposit, Riverside County 443
K. C. Group, Siskiyou County (see Golden Age prospect).
Kaolin in San Bernardino County (see Clay).
Kelly Mine, San Bernardino County 351
Rand Extension Mining Company 351
Kennedy or Altas Fire Brick Company 371–445
Kern County, andaulsite in 452
feldspar and silica in 416–417
Oil Field Development Operations in 78, 220, 404, 541
Keyholes claim, San Bernardino County (see Sidewinder Mine).
Keyston and Lucky Jim feldspar and silica deposit, San Bernardino County 377, 426–427
Keynote Mine, Inyo County 543
Keystone Mine, San Bernardino County 303
Kimble Mine, San Bernardino County (see Verde Antique Marble Quarry).
Kingbird Mine, Yuba County 250
Kings County Oil Field Development Operations in 78, 220, 404, 541
Kingston Mountains iron deposit, San Bernardino County 335

Page
Klamath Hot Springs 62
River Fish and Game District (see Trinity).
Klondike Group, San Bernardino County (see Rincon Mines Company).
Knopf, Eleanora Bliss, cited 536
Kramer Hills Mining Co. (see Shaherald Mining Company).
Kreyenhagen Shale of California, Stratigraphic Significance of the 141–186
, Age of 187
, definition of 142
, Stratigraphic Units and Significant Unconformities 144
, Correlations of Geologic Units 146
, Dual Type Locality 143
, Extent of Thickness of Surface Exposures 147
, Bibliography and Review of Previous work Bearing on the Kreyenhagen Shale Problem 149
, Correlation chart 186
, Diatoms and Silicoflagellates of the 187–201
, Organic Content and Oil Generating Possibilities 189
, Foraminifera of the 202–213
L. and. L Group of Mines, San Bernardino County 274
La Borde feldspar deposit, Riverside County 422
Labradorite (see Feldspar).
Laboratory 114, 231, 471, 550
Ladoo, Raymond B., cited 408
Lai, Chi Fang cited 86
Laizure, C. McK. 66, 139, 261, 415
Lake View Mine, San Bernardino County 274
Lakeside feldspar and silica deposit, San Diego County 429
silica deposit, San Diego County 448
La Majella plant, Monterey County (see Del Monte Products Company).
Lang feldspar and silica deposit, Riverside County 423
silica deposit, Riverside County 443, 448
Langer feldspar and silica deposit, San Diego County 429
La Paloma group of claims, Halloran Springs Mining District, San Bernardino County 327–328
Lapis lazuli in San Bernardino County (see Gems).
sand plant, Monterey County 441
Last Chance claim, San Bernardino County (see Ord Mountain Mine).
feldspar and silica deposit, Riverside County 423
silica deposit, Riverside County 443
group of claims Halloran Springs Mining District, San Bernardino County 328
Lateral Extent of the formation, Kreyenhagen Shale 149
Lavic Mountain manganese deposits, San Bernardino County 337–338
Lawson, A. C., cited 98, 510, 517
Lawton limestone and dolomite deposits, San Bernardino County 385
Lead in Shasta quadrangle 60–61
Mountain Mine, San Bernardino County 351–352, 372
Leastalk Gold and Copper Company 274
Mining Company 274
Le Feure clay deposit, San Bernardino County 374
Lena Louise garnet group, San Bernardino County 382
Leonard and Leck feldspar deposit, San Diego County 429
Group, San Bernardino County (see Black Hawk Tungsten Mine).
Lester Mine, San Bernardino County 303
Leviathan Mine, Alpine County 491
Libby Group, Alpine County 491
Library 115–126, 232–243, 472–484, 551–561
Lily of the Valley prospect, Trinity County 43
Lime, statistics for 1930 227
Limestone and marble in Shasta Quadrangle 61–62
(cement, marble and dolomite) in San Bernardino County 382–389
statistics for 1930 227
Lincoln Clay Products Company 442
Little Annie Mine, San Bernardino County (see Southern Cross).
Betty Mine, San Bernardino County (see Mica).
Jack prospect, San Bernardino County 352
Kingbird Mine, Yuba County (see Kingbird Mine).
Littlejohn feldspar and silica deposit, Riverside County 423
silica deposit, Riverside County 443
Lizzie Bullock property, San Bernardino County 352
Location of San Bernardino County 262
Loftus barite deposit, Shasta County (see Glidden).
Logan, C. A. 66, 139, 246–261, 415, 488
, C. A., cited 58
Lombard and Main Group, San Bernardino County 367
Los Angeles County, cyanite in 457
, feldspar and silica in 417–419
, Oil Field Development Operations in 79–81, 220–221, 404–405, 541
, silica in 438–439
Field Division 66, 139, 262–401, 491
Mine, San Bernardino County (see Brannigan Mine).
Lost Burro Mine, San Bernardino County 303
Horse prospect, Trinity County 43–44
Lead group of claims, Halloran Springs Mining District, San Bernardino County 328

Page
Lucky Betty Mining Company----377–379
Jim Mine, San Bernardino County----274–275, 352
No. 4 claim, San Bernardino County (see Keystone and Lucky Jim feldspar deposit).
No. 1 claim, San Bernardino County (see Keystone and Lucky Jim feldspar deposit).
Strike Group, Siskiyou County---- 44
limestone deposit San Bernardino County----385–386
Lundy, G. E., feldspar deposit, Plumas County---- 420
McAntire, A. B., marble deposit, San Bernardino County---- 386
McCormick, Harry, silica deposit, Placer County---- 442
McDermott fluorspar deposit, San Bernardino County---- 376
McGinnis Mine, San Bernardino County (see Gold Belt Mine).
McKeen Mine, Siskiyou County (see Oro Grande Mining Co.)
McKnight, H. E., Cornish stone deposit, San Bernardino County----379, 445
Mabel Contention and Investment Group of Mines, San Bernardino County----303–304
MacDonald, D. F., cited----29, 30, 32, 35, 43, 49, 54, 55
MacDougal, D. T., cited---- 498
Machado feldspar and silica deposit, Riverside County----423–424
silica deposit, Riverside County---- 443
MacNamara Mining Company (see Nash Mine, Trinity County).
Madera County, feldspar in ---- 419
, silica in ---- 439
Magnesite in San Bernardino County---- 390
, statistics for 1930----228
, uses of ---- 228
Magnesium salts in San Bernardino County---- 392
Mammoth Chief claim, San Bernardino County (see Cave Springs Mining Corporation).
Cons. Mining Company ---- 545
Group of claims, Halloran Springs Mining District, San Bernardino County ---- 328
Mines, Halloran Springs Mining District, San Bernardino County ---- 328
Manganese in San Bernardino County----337–339
Shasta Quadrangle ---- 62
Mansfield barite deposit, San Bernardino County---- 372
Map, claim, of Calico Mining District, San Bernardino County---- 344
portion of Halloran Springs Mining District, San Bernardino County ---- 322
Vanderbilt Mines Co.---- 316
geologic, of San Jacinto Quadrangle, Riverside County---- 541
California ---- 71
Halloran Springs area, San Bernardino County---- 322
index, of California classifying topographic maps from various sources---- 68
of Eliza Mine ---- 33
Golden Eagle Mine ---- 38
Gumboot Mine ---- 41
Hemet Valley and vicinity---- 500
San Bernardino County showing locations of mines and mineral deposits 262
Santa Cruz Island, geologic----opp. page 218
, outline, of California showing location of Shasta Quadrangle---- 2
, relief, of California----opp. page 72
, preparation of a new----73– 77
showing location of principal feldspar and silica deposits, 1931---- 414
Marble in San Bernardino County (see Limestone).
Shasta Quadrangle ----61– 62
Marden feldspar and silica deposit, San Diego County---- 429
silica deposit, San Diego County----448–449
Marine terrace deposits of Santa Cruz Island---- 218
Mariposa County, andalusite in ----452–453
, feldspar in ----419–420
, silica in ----439–440
, sillimanite in ---- 457
Martinez formation of Santa Cruz Island---- 215
Marysville Dredging Company ---- 253
Sand Company, Incorporated---- 259
Massen and Capek bentonite deposit, San Bernardino County---- 381
barite deposit, San Bernardino County---- 372
fluorspar deposit, San Bernardino County (see Afton).
group of claims, San Bernardino County---- 304
Mattoon Mine, Siskiyou County---- 60
May E. Newman Estate silica deposit, Amador County---- 435
Meadows Gulch silica deposit Monterey County---- 441
Mendenhall, W. C. cited---- 507
Merced County, oil field development operations in---- 541
Mercury Mine, Siskiyou County----64– 65
Mesa Grande feldspar and silica deposit, San Diego County---- 429
silica deposit, San Diego County---- 449
Metamorphic rocks in Shasta Quadrangle----7, 14
Methods of mining andalusite deposit in Mono County----461–462
Mica in San Bernardino County (see also Keystone and Lucky Jim feldspar and silica deposit) ---- 390
Microline (see Feldspar).
Midnight claim, San Bernardino County (see Darling Mine).

Page
Millet clay deposit, San Bernardino County 374
Mineral production of San Bernardino County, 1880–1930, table of 262
Yuba County, 1880–1930, table of 247
resources of San Bernardino County 263
Yuba County 246, 248
water in San Bernardino County 390–391
Shasta Quadrangle 62
Minerals and Statistics 113–114, 224–231, 468–469, 547–549
Miner's silica deposit, Tulare County 450
Mining activity in Inyo and Mono counties in July, 1931, Notes on 543
Miocene (Monterey Group) 216–218
Miscellaneous stone in Yuba County 258–261
Missouri Group, San Bernardino County (see Hoosier).
Mizpah group of claims, Halloran Springs Mining District, San Bernardino County 329
-Montana property, San Bernardino County 352–353
-Nevada property, San Bernardino County 353
Mohawk Mine, San Bernardino County 275, 353
Mojave Annex Tungsten Mine, San Bernardino County 367
Marl Company 386
Tungsten Mine, San Bernardino County 368
Molybdenum in Alpine County 491
San Bernardino County 339
Monarch Rand Mining Company (see Garfield Lease, San Bernardino County).
Mondan Fraction claim, San Bernardino County (see Elkhorn Mining Company).
Mono County, andalusite in 453–455, 459–464
and Inyo counties, Notes on Mining Activities in July, 1931 543
Monterey County, feldspar and silica in 420
, silica in 440–441
Group (see Miocene of Santa Cruz Island).
Moon Leasing Company 353
Moore feldspar and silica deposit, San Diego County 429–430
silica deposit, San Deigo County 449
Moraes, L. J., cited 93
Morgan Ranch feldspar deposit, Riverside County 424
silica deposit, Riverside County 443
Morning Star Claim, San Bernardino County (see Cave Springs Mining Corporation).
Mine, San Bernardino County 304–305
Morongo King Mine, San Bernardino County 305
Mine, San Bernardino County 353
Morrison and Carlock Mine, Siskiyou County 44– 45
Mount de Oro Mine, Yuba County 250–251
Hope Mine, Yuba County (see Beehive Mine).
Vernon Mine, Siskiyou County 45– 47
Mountain Copper Company, Ltd., The, cyanide treatment of gossan 129–138
King Group, San Bernardino County 305
Mowry Mines Company 353–354
Mullen prospect, Siskiyou County 47
Muroc silica deposit, Los Angeles County 438
Murray Mining Company 305–306
Museum 114, 231, 470, 550
Myers, W. M., cited 89
Mykrantz feldspar and silica deposit, San Diego County 430
silica deposit, San Diego County 449
Myra Queen Group, San Bernardino County (see, also, Randsburg Associated Mines, Inc.) 354
Myrick Mine, San Bernardino County 306
Napa Junction and Vacaville, Foraminifera of 205
Nash Mine, Trinity County 60
Navajo and Swastika Mines, San Bernardino County 354
Negru, J. S., cited 94
Nelson, R. N., cited 175
Nevada County, andalusite in 455
New Hope (see Mattoon Mine, Siskiyou County).
Tariff and Nonmetallic Products, The 98– 99
Trail magnesite deposit, San Bernardino County 390
Trail Mine, San Bernardino County 275–276
Mining Company (see Mica, San Bernardino County).
York Mine, San Bernardino County (see Sagamore Mine.)
Siskiyou County 47
Mines, San Bernardino County 276
Newman Clay Company (see May E. Newman Estate).
Neys Springs 62
Nichols Mine, San Bernardino County 306
Nieto Placer Group, San Bernardino County 368
Nigger Boy Mine, Siskiyou County 47
Nine-Mile Canyon feldspar deposit, Inyo County 415–416
Niter in San Bernardino County 392
Noble, L. F., cited 498
Nonmetallic minerals in San Bernardino County 370–401
Products, The New Tariff and 98–99

Page

North Rand Group, San Bernardino County (see Randsburg Associated Mines, Inc.).
Star and Big Blue Group of Mines, San Bernardino County 306
Note on a deposit of Andalusite in Mono County, California; Its Occurrence and Technical Importance 459–464
O'Connell limestone deposit, San Bernardino County 386
O'Farrell claim, San Bernardino County (see Elkhorn Mining Company).
O'Harra, Cleophas C., cited 92
O. K. Mine, San Bernardino County 306
Occurrences of Beryl 89–95
Odessa Mine, San Bernardino County (see Calico-Odessa Group of Mines).
Oesterheld, Uber, cited 87
Ogilby cyanite deposits, Imperial County 455–457
Oil Canyon, North of Coalinga, Foraminifera of 203
Field Development Operations 78–82, 220–221, 404–406, 541–542
Generating Possibilities of the Kreyenhagen Shale 189
Old Glory claim, San Bernardino County (see Federal Company).
Gold group, Halloran Springs Mining District, San Bernardino County (see Chesterfield).
Olympus Mine (Paradise), San Bernardino County 306–307
Operations in California of the Pacific Coast Talc Company 100–111
Ophir Mine, San Bernardino County 308
Orange Blossom Extension Mine, San Bernardino County 276
Mining and Milling Company 276
County, oil Field Development Operations in 81, 221, 405, 541
Ord Belt Mine, San Bernardino County 307–308
Mountain Mine, San Bernardino County 276–278
Oregon claim, San Bernardino County (see Zenda Gold Mining Company).
Organic Content and Oil Generating Possibilities of Kreyenhagen Shale 189
Oriental Group, San Bernardino County (see, also, Zenda Gold Mining Company) 354
Oro Fino Group of claims, Halloran Springs Mining District, San Bernardino County 329
Mine, San Bernardino County 308
Grande Gold Mines Company 308
Mining Co. 48–49
Plata Mine, San Bernardino County 354
Orthoclase (see Feldspar).
Ortigalita Creek Area, Foraminifera of 203
Osborne feldspar deposit, San Diego County 430
silica deposit, San Diego County 449
Osdick Group, San Bernardino County 368
Osgood Mine, Siskiyou County (see Lucky Strike Group).
Osmiridium in Yuba County (see Platinum group metals).
Otey silica deposit, Monterey County 441
Owl Group, San Bernardino County (see Rincon Mines Company).
Owls Hole Manganese Mine, San Bernardino County 338
Ozark Mine, San Bernardino County 278, 309
Pacific Coast Aggregates 259–260
Borax Company (see Borosolvay plant, San Bernardino County).
Steel Company (see Kingston Mountains iron deposit, San Bernardino County).
Talc Company's talc deposit (see Tremoline Mine, San Bernardino County).
Company, Operations in California of 100–104
Foundation Corporation (see Valentine Group, San Bernardino County).
Gold Dredging Company 253
Lead and Silver Company (see Silver Rule Mine, San Bernardino County).
Marble Quarries Company 386
Mine, San Diego County 430–431, 449
Minerals and Chemical Company (see Acme Talc Mine, San Bernardino County).
Company (see Lead Mountain Mine, San Bernardino County).
Mines Corporation 278–279
Pack, Robert W., cited 162, 168
Painsville claim, San Bernardino County 309–310
Papoose Mine, San Bernardino County (see Atolia Mining Company).
Paradise Mine, San Bernardino County (see Olympus).
Parker marl deposit, San Bernardino County 386
Parsons, C. L., cited 87
Pathfinder claim, San Bernardino County (see Armistice claim).
Patterson Ranch feldspar and silica deposit, Riverside County 424
silica deposit Riverside County 443
Pauper's Dream and Quidunc Group, San Bernardino County 279
Paymaster Mine (Whitney), Halloran Springs Mining District, San Bernardino County 329–331
Payne, F. R., silica deposit, Placer County 442
Pennsylvania (see Fawcett Mines Co., Siskiyou County).
Penny silica deposit, Riverside County 443–444
Peridotite in Shasta Quadrangle 17
Perris Mining Company 424–425, 444
Perseverance Mine, San Bernardino County 354
Petar, Alice V. 83–97, 451
Philadelphia fluorspar deposit, San Bernardino County 376

Page
Photomicrograph of Abrams schist 8
basaltic rock 25
Copley meta-andesite 16
grandiorite 20, 21
hornblende schist 15
Kersantite 40
Pierce barite deposit, San Bernardino County 372
Pilot Group, San Bernardino County 354
Pilz feldspar deposit, San Diego County 431
silica deposit, San Diego County 449
Piper Group, The, San Bernardino County 279
Pittsburg and Mt. Shasta Mining Company (see Bevis Divide Mining Company).
Piute Mountain Mine, San Bernardino County 310
Placer County, silica in 441–442
Platinum group metals in Yuba County 261
Platinum in Shasta Quadrangle 62
Pleistocene of Santa Cruz Island 218
Pliocene, Upper, of Santa Cruz Island 218
Plumas County, feldspar and silica in 420
Pluth barite deposit, San Bernardino County 373
Poeth Mine, Trinity County 49
Point View Claim No. 1, Fresno County (see Childers feldspar and silica deposit).
Polar Star Mine, The, Placer County 442
Portland Cement Company (see Golden State Portland Cement Company's plant, San Bernardino County).
Potash in San Bernardino County 392–395
Potrero silica deposit, San Diego County 449
Potter bentonite deposit, San Bernardino County 381
Pratt Building Materials Company 260
Prattco Sand Pit No. 4, Monterey County 441
Pre-Cretaceous Rocks, in Santa Cruz Island 215
Preliminary Report on Economic Geology of the Shasta Quadrangle 3–65
Preliminary Report of the Geology of Santa Cruz Island, Santa Barbara County, California 214–219
Preparation of a New Relief Map of California 73–77
Price Group, The, San Bernardino County 279
Prince group of claims, Halloran Springs Mining District, San Bernardino County 331
Producers and Consumers 127, 244, 485, 562
Progress by Federal Departments, Record of 67–73
report of Geologic Branch 402–403, 492–493
Providence Mine, San Bernardino County 354
Pumice in Shasta Quadrangle 62
Pumicite in San Bernardino County 391
Pyrites, statistics for 1930 229
Pyrometric properties of various feldspar mixtures 409
Quaternary in Shasta Quadrangle 14
lavas in Shasta Quadrangle 24
Quartz crystals in San Bernardino County (see Gems).
-diorite, older and younger, of Santa Cruz Island 215
Hill Mine, Siskiyou County 49–52
Mountain silica deposit, Los Angeles County 439
Quicksilver in San Bernardino County 339–340
Shasta Quadrangle 63–65
Quidunc Group, San Bernardino County (see Pauper's Dream).
Rand Consolidated Silver Mining Company, Inc. (see Big Four Mine, San Bernardino County).
Contact property, San Bernardino County 355
Silver Mining Company (see Bray and Bisbee, San Bernardino County.)
United Mining Company 355
, William W. 214–219
Randsburg Associated Mines, Incorporated 355
Silver Mining Company (see California Rand Silver Mine, San Bernardino County) 355
Ransome claim, San Bernardino County (see Elkhorn Mining Company).
Raymond, R. W., cited 490
Raynor group of claims, San Bernardino County (see Federal Company).
Ready Cash claim, San Bernardino County (see Federal Company).
Red Bridge Mine, San Bernardino County 310
Cloud claim, San Bernardino County (see Zenda Gold Mining Company).
Cross and Hidden Treasure groups of manganese claims, San Bernardino County 338–339
Cross Mine, Yuba County 251–252
Jacket claim, San Bernardino County (see Zenda Gold Mining Company).
Redding Field Division 3–65, 129–138, 245–487
Red Rose claim (see Yellow Rose Mine, Trinity County).
Rover Mine, San Bernardino County (see Anaco Mine).
Travertine Deposit, Mono County 544
Reed, R. D., cited 170
Relief Map of California, opp. 72
, preparation of a new 73– 77
Renown Group, Siskiyou County 52– 53
Reutchler Mines Company (see Ophir Mine, San Bernardino County).

Page
Reorganized Silver King Divide Mining Company (see Vanderbilt Mines, San Bernardino County).
Report, Preliminary, on Economic Geology of the Shasta Quadrangle 3- 65
Revenue Group of Mines, Halloran Springs Mining District, San Bernardino County 331
Review of Previous Work Bearing on the Kreyenhagen Shale Problem and Bibliography 149
Reward Mine, San Bernardino County 310-311
Rex and Valencia Hill Group of Mines, San Bernardino County 310
Reynolds Custom Mill, San Bernardino County 368
Rincon Mines Company 279
Rio Vista claim, San Bernardino County (see Ord Mountain Mine).
Riverside County, andalusite in 445
dumortierite in 452
feldspar and silica in 420-426
Geologic Map of San Jacinto Quadrangle in 541
Oil Field Development Operations 221, 405
silica in 442-444
Portland Cement Company feldspar deposit, Riverside County 425
Rolfe, F., and Strong, A. M., cited 498, 517
Roosevelt Mine, San Bernardino County (see Pacific Mines Corporation).
Rosalia Mining and Milling Company 279
Rosamond feldspar and silica deposit, Kern County 416-417
Rose Mine, San Bernardino County 311
Ruby Pearl Mine, Shasta County 53
Ruckman, John Hamilton, cited 159
Rumsey, C. C., feldspar deposit, Plumas County 420
Sacramento Field Division 66, 139, 246-261, 488
Sagamore Mine, San Bernardino County 279
St. Elmo Mine, San Bernardino County 314
Saline Products Company, Inc. 397
Salines in San Bernardino County 391-399
Salmon Schist in Shasta Quadrangle 14
Salt in San Bernardino County 395-397
statistics for 1930 229
Creek, Fresno County, Foraminifera of 203
Sampson, R. J. 66, 407
San Bernardino County, 262-401
, agates in (see gems).
, antimony in 264-265
, asbestos in 370-371
, barite in 371-373
, bentonite in (see fullers earth).
, borax in 392
, calcium fluoride in (see fluorspar).
, celestite in (see strontium).
, cement in (see limestone).
, clay in 373-375
, copper in 265-280
, Cornish stone in (see McKnight, H. E.).
, cuprodescloizite in (see vanadium).
, description of 262
, dolomite in (see limestone).
, feldspar and silica in 376-377, 379, 426-427
, fluorspar in 375-376
, fullers earth in 379-381
, ganister in (see Millet clay deposit; Emsco, also Kennedy or Altas Fire Brick Company).
, garnet in 381-382
, gems in 381
, gold in 280-333
, gypsum in 382
, Halloran Springs Mining District in 321-333
, history of 262
, iron in 333-337
, kaolin in (see clay).
, lapis lazuli in (see gems).
, limestone (cement, marble and dolomite) in 382-389
, location of 262
, magnesite in 390
, magnesium salts in 392
, manganese in 337-339
, map of showing locations of mines and mineral deposits 262
, marble in (see limestone).
, mica in (see, also, Keystone and Lucky Jim feldspar and silica deposit) 390
, mineral production of, 1880-1890, table of 262
, resources of 263
, water in 390-391
, molybdenum in 339
, niter in 392
, nonmetallic minerals in 370-401
, oil field development operations in 81
, potash in 392-395

San Bernardino County—Continued Page
, pumicite in 391
, quartz crystals in (see gems).
, quicksilver in 339–340
, salines in 391–399
, salt in 395–397
, sapphires in (see gems).
, silica in 444–445
, sillimanite in 458
, silver-lead and zinc in 340–364
, soda in 397–399
, strontium in 399
, table of mineral production of, 1880–1930 262
, talc in 339–401
, transportation in 262, 263
, tungsten in 364–368
, turquoise in (see gems).
, vanadium in 368–369
, zinc in (see silver).
Sanborn, Frank 114, 231, 471, 550
Sand in Yuba County (see Miscellaneous stone).
San Diego County, dumortierite in 452
feldspar and silica in 427–431
Oil Field Development Operations in 81–406
silica in 445–449
sillimanite in 458
Sandstone and Conglomerate of Santa Cruz Island 217
Sanford, Samuel, cited 90
San Francisco and San Joaquin Coal Company 432
Field Division 66, 139, 261, 491
San Jacinto Quadrangle, Index map showing location of 497
Block diagram of 503
Riverside County, Geology of South of San Gorgonio Pass 494–540
Rock Products Company (see Hemet Silica Mine, Riverside County).
Joaquin Valley, Foraminifera of 205
Luis Obispo County, Oil Field Development in 81, 406
Mateo County, Oil Field Development Operations in 221, 542
Onofre Breccia of Santa Cruz Island 217
Santa Barbara Beds of Santa Cruz Island 218
County, Oil Field Development Operations in 81, 221, 406, 542
Santa Clara County, Oil Field Development Operations in 406
Cruz County, Oil Field Development Operations in 81
Island, Santa Barbara County, California, Preliminary Report of the Geology of 214–219
Mountains Foraminifera of 205
Fe Group, San Bernardino County (see Wortley Consolidated Mines Company).
Mine, San Bernardino County (see Arlington Mine) 355
San Vicente silica deposits, San Diego County 449
Sapphires in San Bernardino County (see Gems).
Scahller, W. T., cited 452
Schenk, Hubert G., cited 174, 176, 177, 178
Schiedel limestone deposit, San Bernardino County 386–387
Schilling, K. H., cited 169
Schlenzig, J., cited 94
Schrader, F. C., cited 90
Schroeder Mine, Siskiyou County 53
Sebastopol Mine, Mariposa County 453
Sedelmeyer H. A. 73–77
Sedimentary rocks in Shasta Quadrangle 8
Serpentine and peridotite in Shasta Quadrangle 17
Seymour Placer Gold Mines, Ltd., Trinity County 59
Shaherald Mining Company 311–312
Shasta County, silica in 450
Quadrangle, Outline map of California, showing 2
Preliminary Report on Economic Geology of the 3–65
Springs 62
Sheep Creek talc deposits, San Bernardino County 400
Shepard sand pit, Amador County (see Barber).
Ship Mountains Iron Mine, San Bernardino County 335–336
Sidewinder Mine, San Bernardino County 312–313
Sierra Minerals Corporation (see Yellow Jacket Canyon Pumice Deposit).
Significant Uncomformities and Stratigraphic Units of the Kreyenhagen Shale 144
Silica Company of California, Ltd. 436–437
Mining and feldspar deposit, Los Angeles County 419
(Sand and Quartz); (see also Feldspar) 230, 432–450
in Alameda County 432
Amador County 432
Calaveras County 435–436
Contra Costa County 436–437
El Dorado County 437–438
Imperial County 438
Los Angeles County 438–439
Madera County 439

Silica—Continued Page
in Mariposa County ---- 439–440
Monterey County ---- 440–441
Placer County ---- 441–442
Riverside County ---- 442–444
San Bernardino County ---- 444–445
Diego County ---- 445–449
Shasta County ---- 450
Stanislaus County ---- 450
Tulare County ---- 450
Tuolumne County ---- 450
Siliceous Shale of Santa Cruz Island ---- 218
Silicoflagellates of the Kreyenhagen shale, diatoms and ---- 187–201
Sillimanite in Inyo County (see also Andalusite) ---- 457
Mariposa County ---- 457
San Bernardino County ---- 458
San Diego County ---- 458
Silver Basin property, San Bernardino County (see Elkhorn Mining Company).
Bell Development Company ---- 355–356
Belle Mining Company ---- 356
Cliff Mine ---- 356–357
Dome limestone deposit San Bernardino County ---- 387–388
Dome Mine, San Bernardino County ---- 279, 313–314
Giant property, San Bernardino County ---- 357
Glance property, San Bernardino County ---- 357
King group of claims, Halloran Springs Mining District, San Bernardino County ---- 331
Mines, San Bernardino County (see Zenda Gold Mining Company).
property, San Bernardino County ---- 357
Mines, San Bernardino County ---- 357
Lake limestone deposit, San Bernardino County ---- 388
Mine, San Bernardino County ---- 279
-lead and zinc in San Bernardino County ---- 340–364
Lode and Black Water Mines, San Bernardino County ---- 357
Moon property, San Bernardino County ---- 357
Queen Group, San Bernardino County ---- 357
Reef District, San Bernardino County ---- 357
Rule Mine, San Bernardino County ---- 357
Silverman, Alex, cited ---- 86
Silverton Group, San Bernardino County ---- 357
Siskiyou County, Upper Cretaceous (Chico) deposits in ---- 11
Lead Mine, Siskiyou County ---- 60
Skid Road No. 1 Claim, Tulare County ---- 450
Sloan, J. H., feldspar deposit, San Bernardino County ---- 426
Snow silica deposit, El Dorado County ---- 437–438
Storm Mine, San Bernardino County ---- 358
White Marble Company's limestone deposit, San Bernardino County ---- 388
Snowcap limestone deposit, San Bernardino County ---- 388
Sobel, Menahen Merlub, cited ---- 86
Soda in San Bernardino County ---- 397–399
statistics for 1930 ---- 230
Solvay Process Company (see Borosolvay plant, San Bernardino County).
South Telegraph claim, Halloran Springs Mining District, San Bernardino County (see Telegraph Group of Mines).
Southern Cross Mine, San Bernardino County ---- 314
Mining and Milling Company (see Flat Tire Group, San Bernardino County).
Southwestern Portland Cement Company ---- 388–389
Special Articles ---- 83–111, 222, 543–545
Spicer silica deposit, Riverside County ---- 444
Spicky Polish Corporation (see Snow silica deposit, El Dorado County).
Spud Patch diggings, San Bernardino County (see Atolia Mining Company).
Stalder, Walter, cited ---- 169
Standard Cons. Mining Co. ---- 544
Lime Chemical Company (see Standard limestone deposit, San Bernardino County).
limestone deposit, San Bernardino County ---- 389
Mine, San Bernardino County ---- 279–280
Sanitary Company's clay deposit, San Bernardino County ---- 374–375
Manufacturing Company (see Pacific Mine, San Diego County).
Stanislaus County, oil field development operations in ---- 406
Stanley feldspar deposit, Los Angeles County ---- 419
Stanton, Timothy W., cited ---- 150
State Cooperation with U. S. Geological Survey ---- 70–71
Statistics ---- 113–114, 224–231, 468–469, 547–549
gold production in 1930 ---- 547
Stauffer, Clinton R., cited ---- 9
Sterling Gold Mining Company (see Golden Eagle Mine, Siskiyou County); (also Schroeder Mine, Siskiyou County).
Stone, feldspar and silica deposit, Riverside County ---- 425
in Shasta Quadrangle ---- 65
Yuba County (see Miscellaneous).
R. W., cited ---- 90
Stonewall Mine, San Bernardino County ---- 358

Page
Stratigraphic Significance of the Kreyenhagen Shale of California----------141–186
Units and Significant Unconformities of the Kreyenhagen Shale--- 144
Stratigraphy of Santa Cruz Island----------215–218
Strode Mine, Trinity County---------- 54
Strontium in San Bernardino County---------- 399
Structure of Santa Cruz Island---------- 218
Sugar Creek Mining and Milling Co. (see Hathaway prospect, Siskiyou County).
Co. (see Hathaway prospect, Siskiyou County).
Sullivan, Dan, silica deposit, Placer County---------- 442
Sunrise group of claims, Halloran Springs Mining District, San Bernardino County ---------- 331
Sunset Group, Halloran Springs Mining District, San Bernardino County (see C. H. and P. A.
group of claims, Halloran Springs Mining District, San Bernardino County 331
Superior Consolidated Mines Co. (see Johnson and Lewis group, Siskiyou County); (also Morrison and Carlock Mine, Siskiyou County); (New York Mine, Siskiyou County).
Supply Mine, San Bernardino County----------314–315
Swaminathan, V. S., cited----------93
Swastika Mine, San Bernardino County (see Navajo).
Swedish American Mining Co. (see Commodore Mine, Siskiyou County).
Sweetman silica deposit, San Diego County---------- 449
Symons, Henry H.----------113–114, 224–231, 468–469, 547–550
Table of feldspar production in California---------- 407
mineral production by counties, 1930 ---------- 470
substances, 1930---------- 469
, San Bernardino County, 1880–1930---------- 262
, Yuba County, 1880–1930---------- 247
Taff, J. A., cited---------- 173
Talc, Crystalline ----------100–104
in San Bernardino County----------399–401
Products Company deposit, San Bernardino County----------400–401
Tariff and Nonmetallic Products, The New----------98–99
Tehachipi claim, San Bernardino County (see Ord Mountain Mine).
Tehama County Oil Field Developments in---------- 542
Telegraph Group of Mines, Halloran Springs Mining District, San Bernardino County ---------- 332
Temblor Formation of Santa Cruz Island---------- 217
Temescal Canyon silica sand deposit, Riverside County---------- 444
Tertiary and Quaternary lavas in Shasta Quadrangle---------- 24
in Shasta Quadrangle---------- 14
Thelma and Mammoth Group, San Bernardino County---------- 280
Thomas Property, Trinity County---------- 54
Three Colored Marble Quarry, San Bernardino County---------- 389
Three Peaks Prospect, Trinity County---------- 54
States Mine, San Bernardino County---------- 280
Thunderer Group, San Bernardino County (see Calico Odessa Group of Mines).
Tip Top claim, San Bernardino County (see Iron Mountain iron deposit).
Mine, San Bernardino County (see Copper World Mine)---------- 358
Tillie Rand Mine, San Bernardino County---------- 315
Tolman, C. F., cited---------- 175
Tom Reed Mining Company (see Gold Reef Mines, San Bernardino County).
Too Handy Mine, Yuba County---------- 252
Topographic Maps from various sources, Index Map Classifying---------- 68
Total Wreck Mine (Burcham Group) San Bernardino County----------358–359
Townley, Sidney D., cited---------- 498
Trade Dollar claim, San Bernardino County (see Federal Company).
Extension claim, San Bernardino County (see Federal Company).
Transportation in San Bernardino County----------262, 263
Treadwell-Yukon Company---------- 543
Treasury Group, San Bernardino County---------- 368
Treatment Report, The Mountain Copper Company, Ltd.---------- 134
Tremolite Mine (Pacific Coast Talc Company's deposit), San Bernardino County- 401
Triangle Mining Company (see Desert Antimony Mine, San Bernardino County).
Triassic annd Jurassic in Shasta Quadrangle---------- 10
Trinity annd Klamath River Fish and Game District affects Mining----------465–466
Trinity Bonanza King (see Bonanza King claims, Trinity County).
Tucker, W. Burling ----------66, 139, 321, 543
, and Sampson, R. J.----------262–401, 407, 491
Tulare County, Oil Field Development Operations in----------81, 221, 406, 542
silica in---------- 450
Tully feldspar deposit, Riverside County---------- 425
Tungsten in San Bernardino County----------364–368
King Group, San Bernardino County---------- 368
Tuolumne County, cyanite in---------- 457
silica in---------- 450
Turner, H. W., cited---------- 453
Turquoise in San Bernardino County (see Gems).
Tuscarora Mine, San Bernardino County---------- 280
U. S. Group, San Bernardino County---------- 317
Mine, San Bernardino County ---------- 359
Uncle Sam claim, San Bernardino County (see Federal Company).
Union Mine, San Bernardino County (see Atolia Mining Company).

Page
U. S. Bureau of Mines cited 408, 409, 411
Department of Agriculture, Forest Service, cited 3
Weather Bureau, cited 4
Forest Service cited 3
Geological Survey cited 3, 345, 408
Mint aids prospectors 466
Standards cited 413
United Trinity Mines (see Bonanza King claims, Trinity County).
United Trinity (see Bonanza King claims, Trinity County).
Tungsten Copper Mines, San Bernardino County 368
Upper Soda Springs 62
Uses of Beryl 89
Beryllium 85–86
Gypsum 226
Magnesite 228
Utah group of claims, Halloran Springs Mining District, San Bernardino County 332–333
Vacaville and Napa Junction, Foraminifera of 205
Valencia Hill Group, San Bernardino County (see Rex).
Valentine Group, San Bernardino County 359
Vanadium in San Bernardino County 368–369
No. Claim, San Bernardino County (see Silver Cliff Mine).
Vanderbilt feldspar deposit, San Bernardino County 427
Mines, San Bernardino County 317–319
Vaqueros Formation of Santa Cruz Island 216
Vaughan, F. E., cited 498, 508, 520
Vein system of Halloran Springs Mining District, San Bernardino County 323–324
Velvet White Filler deposit, San Bernardino County 375
Ventura County, Oil Field Development Operations in 82, 221, 406, 542
Verde Antique Marble Quarry, San Bernardino County 389
Virginia and Dog Creek Placer, Mono County 545
Dale Mine, San Bernardino County 319–320
Vitrefrax Corporation (see, also, Ogilby cyanite deposits, Imperial County) 451–452
Vogt, J. H. L., cited 83
Volcanics of Santa Cruz Island 217
von Estorff, Fritz E., cited 181
Vulcan iron deposit, San Bernardino County 336–337
Wagner, C. M., cited 169
Mine, Trinity County 54
Wagonwheel Mountain Area, Foraminifera of 204
Walberg Mining Corporation (see Horseshoe Mine, Yuba County).
Walker silica deposit, San Diego County 449
Wall Street claim, San Bernardino County (see Zenda Gold Mining Company).
Wanderer Mine, San Bernardino County 320–321
War Eagle Mine, San Bernardino County 359
Ward and Williams feldspar deposit, San Diego County 431
Waring, Gerald A., cited 390, 498
Warmcastle Soda Springs 62
Warren silica deposit, Riverside County 444
Waterloo Mine, San Bernardino County 359–360
Mining Company (see Zenda Gold Mining Company).
Waterman Mine, San Bernardino County 360
tailings, San Bernardino County 373
Watts, A. S., cited 409, 411
W. L., cited 150
Weaver, Charles E., cited 179
Wedge Fraction claim, San Bernardino County (see Federal Company).
Weir Ranch feldspar and silica deposit, Riverside County 426
silica, Riverside County 444
West End Chemical Company 399
Western Clay and Metals Co. 491
Talc and Magnesite Company's clay deposit, San Bernardino County 375
Company (see Acme Talc Mine, San Bernardino County).
White Nugget group of placer claims, San Bernardino County 321
Rock feldspar deposit, San Bernardino County 379
silica deposit, San Bernardino County 445
, Mariposa County 439–440
Rosa Mine, San Diego County 431
Whitney Mine, Halloran Springs Mining District, San Bernardino County (see Paymaster).
Wicks, Frank R. 100–111
Williams prospect, Siskiyou County 54
Wilmarth, M. G., cited 173
Wilshire Bishop Creek Mine, Inyo County 543
Wilson, Hewitt, cited 411
Winchell, N. H. & A. N., cited 24
Winchester group of claims, San Bernardino County 321
Wolf Creek, Alpine County 489
Wonder claim, San Bernardino County (see Federal Company).
Woodford, A. O., cited 174, 382
Woodhouse, C. D. 459–464
Woodring, W. P., cited 180
Wortley Consolidated Mines Company 360–361
Y. W. Fraction claim, San Bernardino County (see Elkhorn Mining Company).

Page
Yankee Maid Mine, San Bernardino County ---- 321
Yellow Jacket Canyon pumice deposit, Mono County ---- 545
Rose Mine, Trinity County ---- 55
of Texas (see Yellow Rose Mine, Trinity County).
Yokohl Valley feldspar deposits, Tulare County ---- 432
Yuba Consolidated Gold Fields ---- 253, 255–257
County ---- 246–261
, geography of ---- 246
, geology of ---- 246, 248
, gold in ---- 248–258
, dredging in ---- 252–258
, placer mines in ---- 252–253
, quartz mines in ---- 248–252
, gravel in (see Miscellaneous stone).
, iridium in (see Platinum group metals).
, mineral production of, 1880–1930, table of ---- 247
, resources of ---- 246, 248
, miscellaneous stone in ---- 258–261
, osmiridium in (see Platinum group metals).
, platinum group metals in ---- 261
, sand in (see Miscellaneous stone).
, stone in (see Miscellaneous stone).
, table of mineral production of, 1880–1930 ---- 247
River Sand Company ---- 260–261
Yucca Palm group of claims, Halloran Springs Mining District, San Bernardino County ---- 333
Zenda Gold Mining Company ---- 362–364
Zinc in San Bernardino County (see Silver).

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STATE OF CALIFORNIA
GEOLOGY-SHASTA QUADRANGLE

GEOLOGIC BRANCH
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MINES ⚒
PROSPECTS x

ASBESTOS
1 *Jones*

BARITE
2 *Glidden*

GOLD (Lode)
3 *Cherry Hill*
4 *Commodore*
5 *Dewey*
6 *Dorleska*
7 *Eliza*
8 *Gilfeather*
9 *Gold & Nickel*
10 *Golden Age*
11 *Golden Eagle*
12 *Golden Jubilee*
13 *Gold Road*
14 *Gumboot*
15 *Hathaway*
16 *Hazel*
17 *Johnson & Lewis*
18 *Lost Horse*
19 *Morrison & Carlock*
20 *Mt. Vernon*
21 *Mullen*
22 *New York*
23 *Oro Grande*
24 *Quartz Hill*
25 *Renown*
26 *Schroeder*
27 *Strode*
28 *Thomas*
29 *Yellow Rose*

GOLD (Placer) X
30 *Blue Channel*
31 *Fawcett*
32 *Herndon*
33 *Holland*
34 *Mattoon*
35 *Nash*

LEAD
36 *Siskiyou*

QUICKSILVER
37 *Altoona*
38 *Horse Creek*
39 *Mercury*

Position indicated on map by numbers.

SCALE
0 1 2 3 4 5 6 MILES
1930

SEDIMENTARY ROCKS

Qal — *Alluvial and glacial deposits (gravels, etc.)* — CENOZOIC (largely Quaternary)

Kc — *Chico formation (sandstone and conglomerate)* — UPPER CRETACEOUS

Cbd, ls — *Bragdon formation (slates with limestone, ls.)* — CARBONIFEROUS (MISSISSIPPIAN)

P, ls — *Early Paleozoic and possibly pre-Paleozoic sediments and schists. Includes considerable areas of Middle Devonian, Kennett formation, especially in the south half of quadrangle. (shale, slate, sandstone and chert, with limestone, ls. Also much schist.)* — EARLY PALEOZOIC & PRE-PALEOZOIC

METAMORPHIC SEDIMENTARY ROCKS

Asch — *Abrams schist (mica schist)* — PRE-DEVONIAN

IGNEOUS ROCKS

The east half of the quadrangle is largely covered by lavas and some sediments of Tertiary and Quaternary age. (Not shown on map.) — TERTIARY & QUATERNARY

an, dp — *Andesite - an Diorite porphyry and dacite - dp.*

di, grd — *Diorite - di Granodiorite - grd.*

gb — *Gabbro*

sp — *Serpentine and peridotite* — INTRUSIVE ROCKS OF UNKNOWN AGE

METAMORPHIC IGNEOUS ROCKS

gs — *Greenstone and the Copely meta - andesite, undifferentiated.*

Ssch — *Salmon schist (hornblende and chlorite schist)* — PRE-DEVONIAN

AREAL GEOLOGY BY
GEOLOGICAL DEPARTMENT
SOUTHERN PACIFIC COMPANY

ECONOMIC GEOLOGY AND LOCATION OF MINES BY CHARLES V. AVERILL

BASE MAP AFTER
U.S. GEOLOGICAL SURVEY
WITH MODIFICATIONS

ACCOMPANYING PRELIMINARY REPORT ON ECONOMIC GEOLOGY OF THE SHASTA QUADRANGLE

83181—In pocket